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EDUCATIONAL RESEARCH

A Review for
Teachers and all concerned with
Progress in Education

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EDITORIAL

THIS second number of the first volume, apart from the important papers by Sir Cyril Burt and by Dr. C. M. Fleming, contains the first of a new series of articles devoted to the teaching of mathematics. Both this and the series concerned with reading are planned to continue intermittently over this and the next volume. They will not be confined in their attention to the primary school but some at least of the series will be devoted to such work as exists touching the teaching and learning of these subjects in all types of secondary school. Also in this number is an article on Urban-rural Differences which will be followed at intervals by others which are intended to discuss background factors affecting children's learning and progress in school or which should be considered when policy decisions on kinds of educational provision, curricula and teaching method, have to be made.

It is evidently not possible, even in an annual volume the length of a considerable book, to touch upon all subjects where worthwhile research has been done and on which those concerned with education need objective information. This journal, however, is intended to be a working instrument for our colleagues in schools, training colleges, universities and education offices. Editorial notions of priorities are not always an accurate reflection of real ones. We therefore shall be happy to have from our readers suggestions which will help us give the service desired; that is, we should like to hear of broad and special fields of interest on which research information may exist and which readers would like to know about. In some cases it may be possible, if organisers of courses and conferences can let us know well in advance for papers or bibliographies to be produced and published in the journal for those who are likely to attend. Each issue is, however, planned many months in advance and it would only be possible to do this if we get notice about six months before the issue in question is due to appear.

We should like to draw your special attention to two announcements which appear on the last pages of this issue. The first concerns the special binding case for which we have been asked, and which should enable those who wish to do so to keep their copies in good condition. The second concerns the series of occasional publications which is meant to supplement the other aspects of the N.F.E.R.'s Information Services by making available research material of limited appeal but high value.

Finally, may we thank those many people who have written and telephoned to wish the new venture well, and say how valuable they think the journal is and to make cosnstructive suggestions as to how it may be improved. We hope that you will continue to make constructive criticisms and suggestions.

GENERAL ABILITY & SPECIAL APTITUDES

by Cyril Burt

I. Definition of Intelligence

IN the previous issue of this journal Professor Vernon has discussed the naïve and over-simplified notions of intelligence testing, still widely current among teachers and the general public; and his penetrating criticisms have done much to clear the ground. The editor has kindly invited me to summarize my own experience in this field; and my special task, I take it, is to try to rebuild, with what materials are now available, some kind of constructive theory on the vacant space Professor Vernon has thus swept clean.

Our present attempts to assess the abilities of school children by standardized tests have grown out of the pioneer work of Galton and Sully at University College some sixty years ago. It was they who introduced ' child guidance ', by which they understood guidance for the normal and supernormal as well as for the subnormal; and it was the success of their methods which induced the L.C.C. to appoint an official psychologist to carry on their work in the London schools. Meanwhile, in Paris, Binet had already adopted Galton's plan of ' substituting objective measurement for subjective impression ', and applied it to the ' diagnosis of children suffering from innate defects of the mind '. Binet's scale of tests and Galton's techniques for statistical evaluation are still in use today. Hence the first question to be settled is plainly this: what precisely were these investigators, and the educational psychologists who followed them, attempting to measure? After that, we shall have to ask: how far were their claims justified?

As a working model of the human mind Galton, Sully and Binet accepted the traditional scheme more or less as it was; but they introduced two crucial modifications to allow for the new Darwinian principles of heredity and individual variation. Reduced to its essential outlines, therefore, their picture might be compared to that of a two-storeyed building with a vertical partition separating the front and the back. The ground floor represents what is inborn or congenital, while the rooms above form a variable superstructure erected afterwards, and consisting of ' acquired attainments ': in a later version Galton also mentions an ' underground basement ', inhabited by unconscious impulses and memories, which are allowed admission to the ' presence-chamber ' only when summoned by the servants' bell. At the rear of the building, not accessible to the ordinary observer, are housed the busy backroom operatives who keep things going—' the emotions and sentiments, the fears and the desires, that provide the real energy for the day's demands '. In front reside the ' intellectual organizers who supply the necessary guidance and direction ': these form, as it were, a board of managers, and include a presiding chairman, whose function is the general supervision of all activities, and under him a whole hierarchy of subordinate officials—the ' special capacities or aptitudes '.

This threefold dichotomy thus culminates (and here lies the most original feature of Galton's scheme) in the conception of an all-important ' supervisory factor ' which is defined by three essential attributes: it is an *intellectual* factor, as distinct from the emotional and moral; it is *innate* and not acquired; and it is a *general* capacity, and so is contrasted with the more specific ' faculties ' recognized by the scholastic psychologists

and the later phrenologists. For this super-faculty Galton's usual name is ' general ability ', but sometimes, when the argument requires, he speaks of ' natural ability '. In French the word ' habilité ' has acquired a somewhat different connotation; Binet, therefore, adopts the term ' l'intelligence '—a word coined by Cicero and revived by Spencer, whose *Principles of Psychology* had in those days a wide vogue especially in France. In this country ' intelligence ' still had a slightly alien ring. Teachers more often talked of the ' clever ' child; and academic psychologists, to escape the ambiguities that had gathered around the traditional names, preferred the nomenclature introduced by Stout. Instead of ' intellect ' (or intelligence), ' emotion ', and ' will ', they talked of the ' cognitive ', ' affective ', and ' conative ' aspects of mental life: those, for instance, are the terms employed by McDougall in his well-known description of the ' structure of the mind '.

Binet, in explaining how he came to develop his ' scale of tests ', leaves us in no doubt about what he intended to measure. First, he says, we must distinguish between ' intellectual development and character ': emotional or temperamental qualities, he thinks, can best be assessed by observation, not by experimental tests. For measuring acquired attainments he draws up a series of ' pedagogical scales '. And, when he comes to discuss innate capacities, he makes a clear distinction between ' general intelligence ' on the one hand, and ' partial aptitudes ', on the other: the latter, he says, ' will be the object of a later investigation '.

' What meaning then ', he asks, ' are we to give to this word so vague and comprehensive—*l'intelligence?* Nearly all the phenomena with which experimental psychology concerns itself are phenomena of intelligence: sensation, perception, memory, are intellectual manifestations as much as reasoning. . . . It seems to us there is one underlying faculty, of the utmost importance for practical life—the faculty of good sense, common sense, judgment, in a word, the faculty of adapting one's self to circumstances '. Adaptation—' the ability which each individual has of guiding or controlling his adjustments to an ever-changing environment by combining his impressions and organizing his reactions '—this was the Spencerian way of describing how intelligence operates on the simplest levels as on the highest.

Clearly, then, when they spoke of inventing tests for ' intelligence ', Galton, Binet and their followers were using the word as a shorthand label for a highly techincal conception. Thus, when critics like Dr. Heim and Dr. Woolf contend that ' mere environmental conditions—such as differences in schooling or the home background—are more than enough to account for all the observable differences in a mental character like intelligence ', and tell us that ' intelligence involves differences in kind as well as of degree ', they are manifestly using the word in quite another sense. To evade these popular misinterpretations of what was already becoming a colloquial term, Spearman proposed to substitute letters. And in technical discussions I myself have found it helpful to borrow a convention from the physicists and statisticians, and use Greek letters for hypothetical concepts and Roman for empirical assessments, with subscripts to discriminate different sources. Yet even these devices are by no means fool-proof: writers in educational journals gaily talk of a child's ' G ' or ' S ' in the same free and easy fashion as before with no reference whatever to Spearman's own definitions.

But, when all is said, the crucial issue is really this : can we find any tangible evidence to support the conception of an ' innate general intellectual factor ' such as Galton and Binet proposed to measure ? If so, let us keep their name for it; if not, let us bow to our American critics, and expunge the word ' intelligence ' from the scientist's vocabulary.

II. The Evidence

To my mind there can be little question that the trend of recent research fully bears out the earlier distinctions. But, as was to be expected, the advances in psychology, neurology and biology have appreciably modified the fundamental concepts in terms of which those distinctions were expressed. Moreover, the distinctions themselves are now seen to be more like the distinctions between the abstract factors a product than the divisions between the rooms or floors of a material structure. The detailed evidence is discussed in the books and papers cited at the end of this article. Here I need only outline the main converging arguments and the conclusions to which they point.

1. *The Intellectual Factor.* The antithesis between the intellectual aspects of mental activity and the emotional or volitional goes back to Plato and Aristotle. The Greek philosophers relied principally on the observation of outward behaviour. The British school, from Locke and Hume to Ward and Stout, tended to substitute an inward self-observation for the observation of others; and consequently the terminology of the modern psychologist carries a strongly introspective flavour. Such words as ' intellectual ' or ' cognitive ' are apt to suggest that those who are seeking to measure intelligence are concentrating on the narrow field of fully conscious processes — the ' eduction of relations and correlates ' or the ' capacity for abstract thought '—so that ' intellectual ' tends to be contrasted with ' practical ', and thus to exclude it.

From the behaviouristic standpoint the basic distinction is quite simple. To operate any machine—be it a motor-car, a guided missile, a rocket hurtling towards the moon, or the human brain itself—two things are essential: first, power to start and sustain the movement, and secondly, a set of structural mechanisms to guide it towards the goal or target. Plato compares the simplest type of mind to a ship blown by the wind and steered by a rudder. With the fully developed mind, as with the fully-manned warship, the task of steersmanship (*cybernesis*, the noun which gives us our word ' government ') is of necessity more complex, often involving elaborate tactical manoeuvres. But his favourite analogies are drawn from the marshalling of an army or the ' government ' of a well-organized state.

Professor Norbert Wiener, in his book on *The Human Use of Human Beings*, has proposed the adjective ' cybernetic '. I myself would prefer to speak of the ' dynamic ' and the ' syntactic ' aspects of behaviour: (' syn-taxis ' is a Greek military term signifying ' organized direction or guidance '). Here, however, to avoid recondite technicalities I shall follow Professor Vernon's example, and keep to the more familiar name, ' intellectual ', interpreting it in a somewhat Pickwickian fashion. To the teacher who protests that a child's character is quite as important as his intellect I need only say that this aspect has already been covered by Dr. Wall's admirable article on ' motivation '.

2. *The General Factor.* In developing their theory of a *general* factor, Galton and Binet had to rely chiefly on rather speculative conjectures derived from observation, introspection, and the evolutionary doctrines of their day. During the last fifty years, however, far more convincing evidence has become available, derived partly from statistical research and partly from neurological studies.

If we think of the ' factor ' primarily as a statistical abstraction, to be used for predicting efficiency in various concrete tasks, there can be no disputing its value: all types of intellectual achievement are correlated with it, though in varying degrees. But, whether or not we give it a label—' intelligence ', ' G ', or the like—it is admittedly just a hypothetical quantity. Dr. Maddox and others, therefore, contend that any such concept is purely ' metaphysical ', by which they apparently mean that it can have no place in any scientific discussion.

However, all such strictures ignore the far more concrete type of evidence drawn from the field of neurology. The earlier psychologists who ' denied the existence of anything that could fairly be called general intelligence ' were influenced largely by the doctrine of cerebral localization as preached by the physiologists of the nineteenth century. Of these, the oldest, popularly known as ' phrenologists '—a group of scientific workers whose influence on the views of psychologists and educationists has been far greater than is commonly realized—elaborated the theory that there are definite ' organs ' for each of the traditional ' faculties ', embedded in the brain like plums in a Christmas pudding. Post-mortem observations on patients who had suffered from localized disease or damage to the brain, microscopical studies of the cell-structure of different parts of the brain, and experiments on animals whose brains were excited artificially by electrical stimuli, seemed fully to vindicate this theory of localized brain centres, though with important modifications as to detail.

However, at the beginning of the present century many neurologists began to suspect that the localization was by no means so clear-cut as had been previously assumed. In America, Lashley, after a long series of experiments on lower animals, put forward a theory of ' mass-action '. But how are we to interpret the nature of this ' mass action ' of the brain? Sherrington supplied the answer in a pregnant phrase, ' the integrative function of the nervous system ': the business of the brain is to integrate or organize the activities of the individual, and thus to guide and co-ordinate his behaviour so as to meet the needs of the current situation: in a word, its function is what I have called *syntaxis*.

More recently, the anatomists, with their improved microscopical techniques, have demonstrated that the structural differences between one individual's brain and another are quite as striking as those between different brain-areas in the same individual. Sherrington pointed out that almost every tissue—hair, skin, muscle and fat—each has much the same general quality all over the individual's body, with minor regional variations; and he concluded that the nervous tissue could form no exception. Under the microscope the brains of low-grade defectives reveal well-marked peculiarities: as compared with a normal brain, their nerve-cells are scanty and poorly developed; the nerve-fibres that sprout from each cell are few in number and show relatively few ramifications; and both cells and connecting fibres are arranged in a more or less irregular, higglepiggledy fashion, whereas the architecture of the normal brain reveals a neat, systematic and orderly

arrangement, like the circuits in the blue-print for a complex piece of apparatus. And, what is still more instructive, these distinctive qualities are visible in every part of the defective's brain. Thus, as Dr. Scholl, one of our most skilful microscopists, has put it, ' intelligence is a characteristic of the whole brain cortex '.

3. *The Genetic Factor.* However, during recent years the main target for attack has been, not so much the assumption of a general factor, but the assumption that differences in this factor are inherited or innate. ' All men ', we are told, ' are created equal—equal not only in political rights but also in mental capacity: the genius is made not born, and the making of him is due to his privileged environment '.

In my view the confusion that still befogs this bewildering controversy has arisen largely because both the believers in mental inheritance and the sceptics still cling to a theory of heredity that is hopelessly out of date. Most of the psychologists who have supported a hereditarian theory have adopted the old Darwinian notion, which supposed that heredity meant ' the principle that like begets like '. Hence they looked more especially for marked similarities between brothers, or sisters, or children and their parents: if the parents differed widely, then, they argued, the child would be a blend of both, much as Aristotle supposed that, if a leopard mated with a camel, the product would obviously be a giraffe. And so, to demonstrate heredity, they relied, as Pearson did, almost exclusively on coefficients of correlation, which measured the resemblances between members of the same family.

During the opening years of the present century, the hypothesis of particulate inheritance, confirmed as it was by a vast mass of experiments on both animals and plants, completely altered the traditional conception. As the modern biologist sees it, the problem of genetics is to explain, not why like begets like, but why in so many instances like begets unlike. Mendel's principles provide the answer. On the basis of a large amount of data, much of it collected by school teachers, I ventured to suggest, in a paper published over forty years ago, that the application of his principles to psychology would help to account for many puzzling features in the transmission of mental characteristics in man.

The family histories of mental defectives and the manner in which individual differences in intelligence were distributed among the general population strongly suggested that here, as with so many physical characteristics, the underlying tendencies were handed on in accordance with the two-fold principles of unifactorial and multifactorial heredity—the wider and rarer deviations being due usually to a single gene, and the rest to the cumulative effect of a large number of genes. Pearson, however, rejected the whole notion of particulate inheritance, except possibly for certain qualitative traits, like colour blindness. The figures for quantitative or ' graded ' characteristics, such as height and general intelligence, could, so he maintained, be accounted for only by the old Darwinian hypothesis of blended inheritance. Psychologists, too, protested that the Mendelian theory seemed to disrupt the total personality into a mosaic of particular traits; and the majority soon decided that, if the champions of the hereditarian theory disagreed so violently over the explanation of the observable facts, then probably both were wrong.

In America most educationists endorsed Bagley's oft-quoted dictum, namely, that ' the Galtonian doctrine of a hereditary aristocracy of talent is wholly out of keeping with

the principles of democratic education '. The gifts of the gifted, it was argued, are a social inheritance not a biological; and what parents bequeath to their offspring are not their talents but their privileges. Thus, as Gardner Murphy points out in his book on *Human Potentialities*, the environmentalists seemed virtually to assume that educative influences ' acted on an essentially formless human nature ', or at least on a population whose brains were formed after exactly the same pattern in every case. But, if that were so, then the brain would be an organ that was quite unique in the whole biological world. We may readily agree that the anthropoid brain is imbued with an amazing capacity for learning; but such a capacity, like everything else that is part of the creature's inborn nature, is bound to display marked variations from one individual to another.

Today, however, no geneticist would accept Pearson's criticisms as valid. His own calculations were confined to physical characteristics—height, arm-length, dimensions of the head, and so on; and throughout he adopted an over-simplified method of statistical analysis; nor was any allowance made for assortative mating, which is particularly obvious in the case of mental characteristics and in countries with marital traditions like our own. When his data were worked over afresh by Sir Ronald Fisher with a more adequate mathematical procedure, it appeared that the correlations that Pearson himself had calculated tallied almost exactly with the values deduced from a more up-to-date interpretation of the multifactorial theory. Accordingly, my co-workers and I attempted to apply Fisher's techniques to the analysis of the data supplied by mental tests; and here also we found a surprisingly close agreement.

For those who believe in the old-fashioned theory of blended inheritance, and still more for those who insist on the overriding importance of environment, one of the most paradoxical phenomena is the occurrence of exceptionally bright youngsters in families where the personal, cultural and economic conditions of the home would, one might suppose, have foredoomed them to failure. On the Mendelian hypothesis these anomalies are just what we should expect. It implies that the results of marriage, if not marriages themselves, are a lottery. The random mixing of the parental genes produces as great a variety of recombinations and patterns as we should get by shuffling a pack of cards or shaking the coloured chips in a kaleidoscope.

Moreover, the Mendelian theory enables us to correct one highly misleading assumption made both by the supporters of the hereditarian theory and by its more recent critics. Nearly all of them assume that what is inherited are the characteristics actually observed. Today we recognize that (with rare exceptions, such as differences between blood-groups and possibly in eye-colour) all observable characteristics—the crude measurements of intelligence obtained by tests, just as much as the crude measurements of height obtained with a tape-measure—are the compound products of the interaction between the individual's genetic constitution on the one hand and his environment on the other hand. There are no such things as inheritable traits; there are only inheritable tendencies: and tendencies can never be directly measured, but only indirectly estimated.

The Relative Importance of Nature and Nurture. However, the more cautious critics hesitate to deny outright the possibility that differences in intelligence may be innate: what they question is, whether such differences have any appreciable influence as compared with that of the environment. Dr. Floud and Dr. Halsey, for example, have

argued in a recent paper that the tests used in the 11-plus examination are found to favour children from the 'privileged classes' (i.e. the professional and clerical groups): such children do better than the rest simply because their parents were better educated and could, therefore, hand on, by instruction and example, the benefits of their own education. The notion that the parents themselves inherited, and so were able to transmit genetically, a higher measure of general intelligence is in their view wholly mistaken. The most plausible assumption, they maintain, is 'the hypothesis of near randomness in the social distribution of 'intelligence A'' (i.e. of innate intelligence).

How, then, are we to decide between these two alternative views? Whenever we are confronted with two simultaneous influences like heredity and environment, the obvious way to compare their effects is to keep first one and then the other as uniform as possible.

There are numerous orphanages and residential institutions where children of widely different parentage have been brought up from earliest infancy in practically the same environment. When their intelligence is tested, we find that the individual differences are quite as great as they are in the general population; and the case-histories show that the brightest of all are often the illegitimate offspring of fathers from higher social ranks.

To study the effects of environmental differences on children with the same genetic endowment, we can compare assessments for the intelligence of 'identical twins' who have been brought up in different homes. During our work in London schools, Miss Conway and I have been able to trace over forty pairs of this kind: in some cases one twin had been boarded out in a foster home in the slums, while the other had been reared in a cultured and comfortable household. Most of them have been followed up in after life. The detailed figures have been published elsewhere. We found that the correlation between the educational attainments of the twins who have been reared apart was only 0.62, as compared with 0.89 for twins brought up together. On the other hand, the correlation between the assessments for intelligence was as high as 0.88—almost identical with that of twins brought up together.

From all this mass of data, it is possible to deduce, for a given population, an overall figure for the relative influence of nature and nurture. Taking first the crude test-scores, we find that the child's genetic constitution accounts for approximately 77 per cent. of the individual variation—rather less if the tests are merely group tests of a purely verbal type. But no competent psychologist treats the test scores as final. In my own work I have regularly submitted the raw results to the children's teachers; and, wherever discrepancies have emerged, the figures were checked and adjusted by means of further tests and interviews. With these adjusted assessments, genetic constitution appears to account for approximately 87 per cent. of the individual variance.

Professor Vernon reminds us that a number of recent researches claim to have demonstrated 'significant I.Q. rises among feebleminded persons'. But that is merely a reflection on the tests employed or on the way they have been selected or administered; it in no way proves that differences in intelligence are not innate. Nor is the discovery by any means as new as the investigators suppose. When Miss Gaw, Hugh Gordon and I were studying children of gipsies, tramps and canal boat workers, we found that most of them fell below the borderline for feeblemindedness when judged by the Binet tests.

When removed to suitable residential schools, the Binet I.Q's frequently rose by 15 to 20 notches; but the I.Q's obtained with more suitable tests remained virtually unchanged. I know of no reputable psychologist who has ever believed in the alleged ' dogma of the fixity of the I.Q.', or has ever diagnosed mental deficiency on the basis of an I.Q. alone. From my own experience I should rather say that the use of psychological methods of assessment (including intelligence testing) has more often been responsible for rescuing children from unjust condemnation to a special school or institution than for condemning them to ' vegetate there for the whole of their lives '.

As to children at the other end of the scale, I should readily agree that even the best available methods of selection, when applied on one definite occasion, are " bound to do ' injustice ' to at least 5 per cent.", and that, as Mr. Yates and Mr. Pidgeon put it, " some 10 per cent. are likely to be ' wrongly ' allocated ". But I would prefer to mitigate the wording. Terms like ' unreliability ', ' injustice ', and ' wrong ', tempt the layman to regard them as palpable reasons for abolishing a system which is so fraught with error. But such arguments are rather like inferring that, because the predictions of the doctors who examine us for life assurance are so frequently falsified, therefore the premiums that some of us have to pay are ' unjust '. Any alternative scheme of educational selection would do even graver ' injustice ' not only to the children, but also to the ratepayers and taxpayers who defray the cost of ' wrong ' allocations to the more expensive types of education.

Nor can I agree that, because ' we can never observe Intelligence A ' (innate differences due to genetic constitution), therefore it ' would probably be wiser to forget all about it'. On the contrary, I hold that we should do our utmost to refine our methods of detecting such differences. As I tried to point out in *The Backward Child*, the attempt to train the child who is innately dull is not only a depressing experience for all concerned—teacher, child and parent—but tends to divert effort, time and money from the education of those who are not innately dull but merely backward, and therefore susceptible of marked improvement. On the other hand, children of high inborn ability are so scarce that it is the bounden duty of every education authority to ensure that none of them slips unnoticed through the mesh, but that all are caught at the earliest possible age.

III. Special Abilities and Disabilities

The prolonged and animated controversies that have been waged over the subject of general intelligence have, unfortunately, deflected attention from the still more baffling problem of special abilities. Too often it seems tacitly assumed that the notion of aptitudes for specific subjects was long ago decently interred with other hoary relics of the defunct hypotheses of the faculty psychologist. Its chief opponents, the associationists of the early nineteenth century, like their successors of more recent times (the so-called ' behaviourists ') maintained that all mental progress consists simply in the cumulative effects of ' association ' or (in the modern jargon) ' conditioning ': every child, it was supposed, comes into the world equipped with a miscellaneous assortment of well-defined reflexes; and, as a result of experience or tuition, these become ' associated ' or linked to new stimuli or with new and more effective movements. Spencer's theory turned the whole process inside out; in his view the general capacity for adjustment or adaptation

with which every creature is endowed at birth, and which at first is carried out by the body as a whole, tends, as a direct result of growth and maturation, to develop into an increasingly specialized repertory of specialized abilities. There is, as Gesell has recently put it, ' a progressive differentiation within a total action system '.

Most psychologists of the evolutionary school—Bain, Galton, Binet, McDougall—adopted the Spencerian theory. Spearman, on the other hand, at least in his earlier publications, followed the lead of the associationists, and challenged the whole notion of specialized capacities spontaneously maturing. According to his interpretation of the ' factors of the mind ', the so-called ' group factors ', i.e. the ' special abilities ' commonly postulated by the educational psychologists of his day—aptitudes for such subjects as mathematics, literature, art, music, and the like—were merely the outcome of acquired interests or of specialized training at home or at school.

Unfortunately, the neurological evidence is here extremely meagre. A study of the development of cell-branches in the brain indicates that certain areas mature much earlier than others: the centres for movement ripen about ten months after birth, the sensory areas a little later, the areas for speech at about twelve months, and certain association areas (e.g. those in the frontal lobe) not until about four or five years. After that the microscope proves too coarse an instrument to detect any further details. During the school period, therefore, we have to rely for our evidence partly on statistical studies and partly on case studies—especially of children showing marked disabilities in particular subjects.

Systematic surveys usually bring to light occasional cases of specific disability (in reading, for example) among children of normal intelligence long before they have left the infants, department. On the other hand, infantile prodigies (e.g. in numerical calculation and in musical or artistic ability) are reported from time to time by the head teachers themselves. History and biography have already familiarized us with several outstanding instances of precocious genius. Rembrandt painted with an amazing skill at 9; Tennyson covered his slate with childish poems when he was only 8; Mozart published four sonatas at the age of 7; and at the age of $3\frac{1}{2}$ Carl Gauss saved his father 25 thalers by noting a mistake in his addition of the workmen's payroll. But such cases are exceptional. When we turn to the statistical data, it proves exceedingly difficult, before the age of 9 or 10, to demonstrate anything more than the all-important ' general factor '. The influence of special abilities (' group factors ', as the statistician likes to call them) is so slight that, unless the surveys cover a vast number of cases, the evidence is altogether swamped by the ' errors ' of measurement and sampling.

By the age of 11, however, there are clear signs of a distinction between two broad types: some children seem to belong to what has been termed (in a rather narrow sense) the ' intellectual ' or academic type; these, if they are of high intelligence, are obvious candidates for the grammar school; others belong rather to a more practical or mechanical type; and these, provided they possess the requisite intelligence, are better suited to an education with a technical bias. Of course, here as elsewhere, the so-called ' types ' are no more than emergent tendencies. Take a random sample of a hundred 11-year-olds, and, on the basis of the most reliable assessments procurable, divide them into three approximately equal subgroups of about 33 or 34 pupils—those who are good at grammar

school work, those who are poor at it, and those who are merely average; next reclassify them into those who are good at technical work, those who are poor at it, and those who are merely average: you will then find that, out of the 33 who were good at technical work, as many as 20 will in all probability be good at grammar school work, and only 3 definitely poor at it: in other words, at this early age success in either type of work still depends far less on special aptitude than on an all-round mental efficiency which manifests itself to a varying extent in nearly every type of subject.

Towards puberty the 'intellectual' group tend to subdivide into those of a predominantly verbal type and those with a special facility for numerical work. At the same time there are growing indications of a rich variety of aptitudes provided a sufficiently broad range of tests is employed. Thus, throughout the years of mental growth there appears to be, as Spencer maintained, a continual tendency towards differentiation and specialization.

Of the more specialized disabilities, space allows me to mention only those that bear most directly on the work of the classroom. To begin with, there can be little doubt that several sensory defects run in certain families, e.g. defects of form vision (myopia, hypermetropia, astigmatism, and the like), as well as defects of colour vision which indeed have provided some of the most instructive specimens of Mendelian inheritance in man. Differences in mental imagery likewise seem to be transmitted biologically: some children are almost destitute of visual imagery; others of auditory imagery. But of all such disabilities, the most detrimental is weakness in mechanical memory or retentiveness. In the work of the school, the teacher teaches and the child is expected to learn: hence, pupils who find it hard to retain what they have learnt are apt to drop behindhand in the day-to-day work of the classroom. Defective memory provides one of the commonest explanations why children of comparatively high intelligence at times appear to be educationally subnormal: conversely, in the more mechanical work of the classroom dull children with retentive memories may at times produce unexpectedly good scores in standardized tests, and so present the familiar anomalies noted by those who calculate 'achievement quotients'. As I have shown elsewhere, once these special disabilities have been detected, any appropriate changes made in the teaching methods, the backward child can often be transformed into a perfectly normal scholar.

IV. Practical Implicationa

Let us now recapitulate the main conclusions and see what practical corollaries may be drawn.

1. If, as now seems beyond dispute, each pupil comes into the world with a unique genetic constitution, which in its turn produces wide individual differences in both general and special capacities, then it is plainly imperative that both teachers and local authorities should take full account of such differences in their efforts to provide an education which will (in the words of the Act) be adapted to each child's 'ability and aptitude'. At the primary stage, as we have seen, it is differences in general intelligence that are of paramount influence. When we take a cross-section of the school population at the age of ten, we find that, in a random sample of a thousand, the brightest will have a mental age of 15 and the dullest one of barely 5. By the age of 10 or 11, therefore, some kind of provisional

selection is absolutely essential: in my view it should start much earlier. Provided, as his capacities develop or decline, the child is free to swim from one stream to another, streaming in itself makes for efficiency all round; and, contrary to the prevailing notion, segregation is only needed for subjects that are closely dependent on general intelligence, not for every aspect of youthful life.

2. Since genetic constitution merely determines growth-tendencies, and since the child's observable progress and performance are the resultant of innumerable factors, both internal and external, we could never hope, even with the most precise specification of the newborn infant's equipment of genes, to make infallible predictions about his ultimate level. For the individual pupil the most reliable assessments are unquestionably those compiled by an experienced, observant and well-trained teacher who has watched and recorded his progress from the earliest possible age. But standards differ from one teacher to another, and from school to school. Tests supply a quick and easy way of securing provisional estimates on a scale which is, or should be, the same for all; even so, skill and training are needed to choose, apply and interpret them. Intelligence tests were originally introduced in the L.C.C. schools as a supplementary and standardized procedure for screening those whose backwardness seemed attributable to irremediable defects, and they still have their uses in this field; but they have since proved still more valuable as an accessory instrument for bringing to light what after all are the most precious of our national assets, namely, children of outstanding ability.

3. Owing to variations in environmental conditions and the inevitable fluctuations during growth and maturation, every attempt at allocating pupils must be something of a gamble. But this reflects neither on the efficiency of the tests nor on those who use them; still less is it a reason for denying the importance of inborn differences. It follows that, if we wish to make absolutely certain that the brightest of the bright—say the most brilliant 5 per cent.—will be allotted to a grammar school, then in practice we must cream off a top layer of about 20 per cent. For borderline candidates the accuracy of the assessments can undoubtedly be improved if the results of the group examination are submitted to the teachers or at least compared with the teachers' personal estimates and if cases showing a discrepancy are then subjected to a further check by interview or individual testing. Whether the ultimate gain to the community, and to the borderline children themselves, will be sufficient to offset the additional expense, must be for the education authorities to decide.

4. For those who are unfamiliar with more technical methods of assessment the I.Q. (preferably computed indirectly from percentile rank on a standard scale) furnishes a simple and intelligible unit. But the idea of an H.Q. for I.Q's (if I may so describe it) belongs to the realm of scientific fiction rather than of genuine science. No competent psychologist has ever supposed that an I.Q. can be exactly ascertained, much less that it will remain immutable for each individual child: on the contrary, the earliest researches on mental growth revealed discernible fluctuations from year to year, especially towards the period of puberty. In areas where the threefold classification of secondary schools is operative, an assessment of each child's ability must, of course, be made at 11-plus, but in my view it is equally important to make it at 11-minus—indeed, as soon as possible after the child has entered school. But such assessments should always be checked and

rechecked; and, when at length the child has been allocated to a secondary school, it is desirable that the decision should be subject to review and that a working procedure should be available for transferring or re-transferring pupils during the years that follow.

5. The emergence or maturation of special aptitudes during the pubertal period is an added ground for continuing the study of each individual child throughout his school life. At present they are too often overlooked. Even in the primary school special disabilities may sometimes handicap the brightest; and just because they are specific, it is nearly always possible, as we have seen, by changing the method of teaching, to circumvent any handicap that may thus be imposed. In the secondary school special aptitudes may be almost as important as general intelligence in determining the suitability of a particular type of education or a particular occupational career. As it is, the venerable tradition of the grammar school leads us still to place too much weight on verbal and literary abilities: even our intelligence tests are predominantly verbal. In a technological age—an age of turbo-generators and atomic piles, of automation and electronic control—it is equally essential to discover pupils with aptitudes for technological work.

6. Of the emotional reactions which these administrative changes are liable to engender, I have said little or nothing. In the past children of the same family varied as widely as they do today; but now, with the educational ladder free to all, the bright boy from the poorest home is able to climb, rung by rung, to the highest social rank. However, the different social classes vary far more in their ideals, their traditions, their accent and vocabulary, their code of morals and manners, than they do in actual ability. Hence, the new entrant to the grammar school and university, like the old ' scholarship lad ', is apt to feel declassé: he has been uprooted from the group into which he was born, and has no roots in the new. The result is a sense of double frustration, fraught with all kinds of dangers, which Mr. Hoggatt (who has himself been through it all) has graphically described in a book that every teacher should read. Except for a few casual references in studies of maladjustment and delinquency, it is a problem which so far has been almost entirely neglected; and it is one for which much may be done by the schools that now receive the new type of pupil.

In spite of popular prejudice there is no insuperable conflict between equality as a principle of justice and inequality as a fact of genetics. In education equal opportunity means opportunity to make the most of differences that are innate. The ideal is a free and fair chance for each individual, not to rise to the same occupational rank as everyone else, but to develop the peculiar gifts and virtues with which he is endowed—high intelligence if he possesses it, if not, whatever qualities of body, mind, or character are latent within him, irrespective of his intellectual level. In this way and in this way alone will he be able to contribute his utmost to the community, and at the same time live his own life to the full.

7. Finally, as must have been obvious at every stage of our discussion, there are innumerable issues crying out for further research, where the teacher himself can make the most valuable contributions. I have room to touch upon only one or two.

On the practical side we need far more follow-up studies to ascertain where existing methods of selection are faulty and how they can be improved. At present most of the investigations on educational psychology are being carried out by young research-students,

often from overseas, with little or no inside experience of classroom conditions or of the teachers' special point of view. The most appropriate investigator (as the L.C.C. long ago realized) would be a psychologist who is himself a member of the education staff and is thus familiar at first hand with the schools in his area and their various problems. Armed with official authority he can plan his experiments more effectively and call for data that are often confidential; while at the same time he will be able to assist or co-ordinate the efforts of teachers in their own investigations.

On the theoretical side the fundamental questions must be left in the main to the psychological laboratory. However, at this transitional stage in our educational organization, the more pressing problems are problems in mental biology—the determination of the genetic basis, not merely of general intelligence, but of special abilities and disabilities, and of peculiarities of temperament and character. These are essentially problems for the field worker. During the earlier years of the century it was the teachers themselves who provided much of the requisite data. They compiled case histories; they traced the pedigrees of families showing conspicuous mental characteristics; and, by their experienced inquiries, they did much to pave the way for what Binet called the ' new psychogenetic approach '. Galton's studies of one-egg twins were mainly based on details obtained in this way; and, if the Mendelian hypothesis be accepted, almost equally instructive material can be secured by comparing the offspring of consanguineous marriages or of parents or grandparents who have married more than once.

Owing to the revolutionary changes that have taken place during the past fifty years, not only in environmental conditions, but in our whole mating system, all these problems require to be worked over afresh in the light of modern genetic theories. Social and geographical barriers have broken down; populations in isolated areas that have been inbred for centuries are now shifting to outbreeding. Changes such as these, as every genealogist is aware, not only furnish some of the most instructive types of source-material, but are also likely to exercise a profound effect on the subsequent history of the group. Surveys and factorial studies, carried out over long periods of time as well as over wide areas, are equally desirable. All these, however, are but a sample of the many ways in which the teacher in the school can aid in the advancement of psychological knowledge. The National Foundation for Educational Research, as we know, is always ready to serve as a co-ordinating or supervising centre.

In a prophetic fantasy which he entitles *The Rise of Meritocracy* Dr. Michael Young has vividly depicted the advantages that might accrue to the community and to civilization if ' educational experts ' could systematically assess the potentialities of every individual as soon as he enters school, and then allot the most suitable training for each one—whether normal, subnormal, or supernormal. Nor does he overlook the drawbacks and possible dangers. And the lesson of it all is that reforms of the type envisaged must be based on an appreciation of the facts, not on political aspirations. Facts, however, can only be ascertained by impartial inquiry. Hence the two crying needs of the moment are a more scientific attitude towards the issues involved and a more determined organization of scientific research.

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THE DEVELOPMENT OF NUMBER CONCEPTS IN YOUNG CHILDREN

by J. B. Biggs

Introduction

BASIC to any attempt to improve the teaching of mathematics is a knowledge of the way in which young children form number concepts, and how the teaching of arithmetic and number experiences in the primary school affect this growth. Although arithmetic itself has been the subject of research for many years, much of the reported material in the extensive literature tends to be fragmentary and disjointed. It seems, therefore, that an attempt should be made at the outset to sketch a psychological scheme of interpretation on which a systematic body of knowledge, more directly useful to teachers, may be built.

Buswell, in a review of the previous 20 years of research in arithmetic, has a similar sort of thing in mind when he writes that too much time has been spent in dealing with incidental problems—analyses of textbooks and curricula, comparisons of specific techniques of teaching given topics, and so forth—and far too little on the thinking being done by children as they learn. When this second question can be answered, i.e. when a systematic psychology of arithmetic emerges, the former incidental problems will be well on the way towards a solution. The emphasis, in other words, is to be changed from *what* children know to *how* they come to know. Largely because of the difficulty in undertaking such research, there is, with the important exception of Piaget's work, little to guide us on this second and crucial point. The Scottish Council, for example, reports a survey of the extent of number knowledge amongst children entering infant school. This is certainly useful information; but much more useful would be an account of how these number concepts develop in the first place, and how the teacher can fit her method of teaching to this natural process of concept development.

The more important questions seem then to fall into two groups: (*a*) how does the child acquire understanding of number concepts? and (*b*) what are the implications which a knowledge of this growth has for our teaching methods, the curriculum content, the age at which any concept or process might be taught, and so on?

It can readily be seen how this second group of questions is dependent on the first. Appropriateness of method and the placement of topics in the curriculum, for instance, are to be determined not so much by the logical demands of the subject to be taught, as by the psychological demands or limits of the child. It is an evident waste of time to teach a child decimals, say, if his mental equipment is at present inadequate to allow him to understand them. It could be argued that the concept .1 is logically the same as 10, in relation to 1; but psychologically this may be beyond the grasp of children who can in fact understand—functionally at any rate—the latter relation.

The actual contents of the curriculum may be governed in some part by educational aims and philosophies, and by such external factors as eventual social and vocational requirements; nevertheless, the real content must inevitably be limited by the understanding of the pupil, i.e. by what he can 'take'. In the past, this has been in part determined by a so-called common sense psychology; by such assumptions, for example, that drill develops a disciplined mind; or that mere continued exposure to bodies of knowledge will eventually result in some at least being assimilated. Modern educationists are somewhat more humble in their psychological claims.

It is worthwhile, then, to review such theoretical contributions as we have to the psychology of number. The most thoroughgoing and potentially fruitful source of relevant theory is to be found in the work of the Swiss psychologist, Piaget; and it is on this that much of what follows is based. His researches were motivated in the first place by a somewhat philosophical aim—to find a genetic basis for a theory of knowledge—and are only incidentally, as it were, a contribution to education. In spite of this, his work, and that of his students and more recent followers, is of paramount importance to arithmetic teachers, especially those concerned with primary school pupils.

Piaget's Contribution to the Psychology of Thinking

Piaget has been interested in mental growth in general and particularly in the way in which children develop concepts of space, time, causality, reality and number. His method of study was to interview children individually, giving them simple but highly ingenious tests to complete, and questioning them afterwards on the reasons for their responses. On the basis of many years of such work he distinguishes several stages of development paralleled in most of the variables he investigated.

In *The Psychology of Intelligence* he defines the following general levels of intellectual growth, giving *approximate* age levels in each case:

I. Non-operational (Birth—2 years). This he also calls the *Sensory-Motor* stage. The infant is solely concerned with objects *qua* objects—if a ball is temporally hidden from the baby, for him it ceases to exist. Having no power to construct a symbol for the ball—i.e. lacking the concept 'ball'—the infant is completely tied to the here-and-now world of palpable objects.

II. Pre-operational. (1) *Transductive Period* (2—4 years). As the abstraction from action to thought is made, memory becomes possible. The object, with the development of language, is symbolised, however crudely, by a thought process which can be retained in the mind. Even so, there is no distinction as yet between the general and the particular which is an essential part of the formation of true concepts. The three-year-old uses what Piaget calls a 'pre-concept'; for example, he does not know whether he eats the same grapefruit for breakfast each morning or a different one since he lacks the general concept of a class of object—grapefruit—to which a single fruit belongs.

(2) *Intuitive Period* (4—7 years). Here the child's thought processes are governed entirely by global perception—if an object *looks* bigger than another, it *is* bigger, regardless of the circumstances. Thus, another child who is standing close by is pronounced to be taller than a man some distance

away. His conceptual apparatus is as yet unable to regulate his sense impressions: the imaginings and fantasies of the six-year-old are thus not so imaginative or fantastic as appears to amused—or horrified—adults.

III. Operational. (1) *Concrete* (7—11 years). Two important principles become available at this stage. The first is the reversibility of thought. This is exemplified in the test situation where the child is asked to lay out a glass for each of several bottles on the table—a task even very young children can do without much difficulty—and he will see that if the line of glasses exactly corresponds in length to the line of bottles, there is the same number of glasses as bottles. However, if the glasses are pushed together, the five-year-old would say that there are now too many bottles (because the line of bottles is longer) and would 'equalise' the situation by putting out more glasses. He thus makes his judgment on what he immediately sees before him, without any reference to his preceding actions. His thought processes, in other words, are irreversible. Taking a more mathematical example, the proposition $2 + 6 = 8$ necessarily implies its reverse, $8 - 6 = 2$. A five-year-old may be 'taught' to perform both these sums with accuracy (as indeed may a parrot), but he will fail to appreciate the fact that the second is the opposite of, and is implied in, the first. When he can appreciate this, it means psychologically that he is able to range his thought backwards and forwards over a complete experience.

This principle of reversibility permits him to make the next important step which is to discover the constant elements in such operations. Thus, when he repeatedly finds that $2 + 6 = 8$ he will conclude that 8 is always 8, whether it is 8 rabbits, motor-cars, pussies or just plain units; similarly for 2 and 6. In fact, there is some evidence to show that an insistence on 'enlivening' number work which is apparent in many infant schools may actually impede the young child's progress in understanding the essential constancy of number meanings. Stern, as we shall see later, adds strong support for this view in her book, *Children Discover Arithmetic.*

The principle of conservation, as this new development is called, is already well recognised in the physical sciences and here is extended to the conceptual world of thought. The notion of set, or of any material or conceptual closed system, requires that in any transformation of its components, or their interrelationships, the total set will remain unchanged. The concept '4', for example, still remains constant whether it is regarded as $3 + 1$, or as $2 + 2$. Piaget tested this notion of conservation with his celebrated liquid and glass experiments, and found three stages in the development of the concept. At first (absence of conservation) children would respond that the quantity of liquid increases or decreases according to the size or number of its containers. Thus, if a glass of lemonade is poured into a taller but thinner glass, the five-year-old will almost invariably respond that there is more in the second glass (because the level is higher) or that there is less (because the glass is narrower). Next, at about $5\frac{1}{2}$—6 years, there is an intermediate stage when the child will judge correctly that there has been no change in volume as long as

the second glass is not *too* tall or *too* thin—i.e. ' common-sense ' triumphs over crude perceptual evidence if they are not too much at variance from each other. If the difference is too marked, however, the child will revert to the perceptual criterion.

At the third stage, constancy becomes immediately apparent—indeed, seven-year-olds tend to get a trifle impatient at being asked what is, at this stage, all too obvious. By substituting beads for water, Piaget obtained similar evidence, and drew similar conclusions, for the conservation of discrete (unitary) quantities. All forms of constancy are not, however, attained at this age. Inhelder points out that at seven years the child can arrive at conservation of matter (by moulding a ball of plasticene into a long strip), but it is not until ten that he understands conservation of mass or weight, and eleven for conservation of volume.

The child at this level, then, is capable of a limited form of reasoning, as long as it is tied to his own concrete experience. He is able to generalise and to form valid concepts but only so far as they are founded in and known immediately through experience.

(2) *Formal* (11 years and over). At early adolescence, ability to perform abstract operations becomes apparent. Children can, for instance, pay attention to the form of an argument or situation and ignore the actual content. They can construct a rational *as-if* world; set up hypotheses and deduce the logical consequences. This liberation from the bonds of the concrete is achieved by the final stage of concept formation whereby mental structures are ' decentred ' from perception.

The differences between this and the previous stages can be seen by referring to Inhelder's work where children were asked to discover elementary physical laws by manipulating simple apparatus. At the pre-operational stage, children played with the apparatus in random fashion, quite without any notion of an underlying principle. Subjects at the concrete operational level varied one condition at a time, and could note a cause-and-effect relation, but in particular instances only. Adolescents, however, carefully and systematically controlled the known variables and thus induced, in true scientific manner, the explanatory principle behind the observed phenomena.

This final feat of abstraction is impossible at an earlier age or lower level of mental development. It is worth noting in passing that only at secondary school level can we thus be reasonably sure that topics of a formal nature—ratio and proportion, algebra, scientific method, theoretical geometry, logic, etc.—are potentially fully understandable to children. On the other hand, as Peel warns us, this does not mean that all our thought after the age of 11 years is at the formal operational level. We all, he says, tend to aspire to the condition of operational thinking, but if the tasks are very new and very difficult, then even the adult will find himself having to move through some of the preliminary stages.

The Child's Conception of Number

The earliest age at which it would be at all possible to observe behaviour remotely relevant to the formation of number concepts would be at the pre-operational stage. Verbalisation is a most important pre-condition, but is not, in itself, sufficient—as is evidenced by the infant who can happily count (correctly) up to 10 or more without the slightest clue as to how to *apply* these pleasant and diverting sound-patterns. Objective evidence for this is found in Descoeudres' work. She discovered that, whereas at three years most children could count up to 5, yet they were unable to perform matching operations (where some understanding of the meaning of number is required) beyond 3 objects. Five-year-olds, on the average, could count up to 9, but were able to attach number names to only 3 or 4 objects.

To recapitulate briefly : in Piaget's view, concept formation is the result of ' action experience ' building up mental structures which then serve as a reference system for the interpretation of direct sensory—or ' physical '—experience. These mental structures permit reasoning as such; basically, they are abstractions or generalisations from concrete experiences which impose order upon direct perceptual events. We have seen, for example, in the glass and bottles experiments that plain global perception is apt to be most misleading. Prerequisite to all thought are the basic structures of reversability and conservation. We shall now look at some of those additional ones which are specific to mathematics.

Logically, our number system is composed of two basic processes—cardination and ordination. Any number, that is to say, may be regarded as possessing a definite characteristic or class property, e.g. ' four-ness '; and also as indicating a place in a series, e.g. the fourth member of the series, preceding 5 and succeeding 3. It is worth pointing out, as Churchill has also noted, that emphasis in infant schools is all too frequently only on the cardinal properties of number which themselves cannot be understood without the ' action experience ' of ordination: on the other hand, systems of teaching which are based only on counting are equally remiss. Mere verbal counting, as Piaget insists and Descoeudres has demonstrated, does not adequately account for all the ordinal properties although it is vital for both cardinal and ordinal understanding.

One of the important features of cardination is the ability to classify. In the experiment with bottles and glasses it will be remembered that, despite appearances, the notion of invariance of class ' bottle ' in relation to class ' glass ' was of prime importance. This goes a stage further when the child is asked to classify objects and then to combine them into a new class—an operation which is the basis of ordinary addition. To demonstrate this, Piaget gave his children some brown beads and a much smaller quantity of white ones; both groups of beads were made of wood, i.e. they all fell under the concept 'wooden bead '. The child at stage one correctly maintained that there were more brown ones than white ones, and agreeing that both brown and white are wooden, would then go on to make the surprising claim that a necklace made out of brown beads would be longer than one made out of *wooden* beads ' because there are more brown ones than wooden ones '. Not until the age of seven are Piaget's children able to hold two concepts in mind simultaneously and thus to grasp the logical (and mathematical) truth that the part is never greater than the whole. In other words, until children do see this, they are

incapable of *understanding* addition or subtraction. The point at issue here, though, is the demonstrated relation between classifying and the recognition that a class, or combination of classes, has a definite number of elements.

There are also three stages in the development of ordination. At first the child is only capable of global ' greater than ' or ' less than ' judgments. He is thus able to construct a simple series, say of sticks of varying lengths, but such a series is strictly limited in size. At the second stage he is able to seriate well enough, but when the series is disarranged internally he is unable to correct it by reference to the number of elements preceding a given place in it. His understanding, that is, is qualitative, not truly quantitative. Finally, cardination is co-ordinated into the process so that each element in the series has a definite value; that this value is determined by the number of preceding elements; and that the unit value is constant, i.e. the difference between 2 and 3, say, is the same as that between any other adjacent members of the series, e.g. 51 and 52.

These stages may be illustrated by a study reported by Churchill. One of her tests involved the use of Tillich bricks. These are blocks ranging in size from the smallest unit (cube) to ten times the length of the cube, the unit sizes being painted in colour along the sides of the rectangular blocks. It was thus possible to build a series either by reference to the length of a block in relation to the others (qualitative seriation), or by counting the units marked off on the larger blocks—in effect, determining its cardinal value (numerical seriation). Churchill found that very few five-year-olds could at first complete a ten-step series and those who could (2 out of 16) were unable to answer questions relating to the positional value of the elements in the series. Later, however, stage three type responses were obtained in which the children spontaneously counted the squares on each brick to determine its position in the series; i.e. the cardinal and ordinal aspects had become integrated. Further, these children could justify the position of a given item by saying that ' it was a four ' (i.e. four bands or units were painted on the side of the block) and therefore occupied *fourth* position. In contrast, typical stage one and two responses were: ' Because it's littler ' or simply, ' I don't know '.

These, then, are some of the basic processes which Piaget investigated. It would be pointless following him through *The Child's Conception of Number* in tortuous detail. The major mechanisms have been outlined above and there is ample evidence here for us to draw some vital, if not too comforting, conclusions. First, however, a note on interpretation. Much of the data comes, especially in the earlier stages, from Piaget's own three children; hardly, as Berlyne puts it, ' the children of Average Man! ' Further, one may feel some qualms in generalising from the responses of a small and biassed sample of Swiss children to the situation of the English Infant and Junior school. However, considering the intensive and clinical nature of his research, and that his main point is to indicate the sequential and structured nature of mental growth, these objections are more specious than real. Most of the comparative evidence we have—and there is an ever-increasing amount—differs from Piaget's conclusions in detail only.

The University of Birmingham, for instance, has been carrying out a good deal of work to test and generalise Piaget's conclusions. Amongst these studies, one reported by Carpenter relates to age levels at which changes take place. She administered some of Piaget's tests to a group of children, aged from 5 to 9 years, and ranging, in each age

group, from dull through average to bright. She found the same sequential nature of intellectual development but the ages at which the stages occurred varied markedly from those reported by Piaget. She suggests that this may partly be due to the degree to which the child is familiar with the test material and partly to the amount of interest the test material itself arouses in the child (the children did better on one test when the material consisted of model trains instead of plain balls). Probably her most interesting finding, however, was that there was far greater agreement between conceptual development and *mental* age than with chronological age *per se*. Unfortunately, Piaget related development to the latter only.

Lunzer confirmed Carpenter's findings with a larger sample. He concludes that, as expected, their work is in agreement with the findings of Piaget but that stage level is better determined by mental than by chronological age. Further, it is suggested that where the context of a problem is familiar, a subject can tackle such a problem at a higher level than where the problem is set in an unfamiliar context. The teacher, he goes on to say, might by frequency of presentation of a type of problem thus facilitate the reasoning process in his pupils—" in so doing the teacher is deliberately educating children, rather than waiting for development to take its ' natural ' course."

A recent study conducted by Churchill confirms this view that the Piagetian stages are not purely maturational; i.e. that environmental influences can be important. She criticizes Piaget for not paying sufficient attention to the influence of cultural and educational factors on the developmental process—for " if children of five or six years have as little understanding of the meaning of numbers as Piaget suggests, then the little sum cards they fill up every day in many schools must hold a very different meaning from the one intended by the teacher, and they could be more profitably occupied in other activities."

Sixteen five-year-old children were used in the enquiry. They were first tested by a series of the Piaget type and the group divided into two so that mean initial scores were the same. The experimental group was given a programme of play situations involving grouping, seriating, matching and ordering so that the children " might learn something about the nature of number operations and relations." The control group simply carried on with their usual Infant school routine. The testing was repeated after a month. It was found that the number understanding of the experimental group had improved significantly over that of the control group, as is indicated by the much larger number of correct test responses and the higher proportion of stage three responses.

These results in the main support Piaget's own conclusions but there are two practical modifications: the sequence of stages is apparently not so invariant as at first supposed (some children, for instance, seemed to by-pass stage two); and secondly, the process may be hastened and facilitated by appropriate experiences—it is not essential, in other words, to wait for the gradual maturing of inherited potentialities.

On the other hand, there has been some violent disagreement over his work. Much of this is purely theoretical—e.g. Bunt's criticism concerning the philosophical use of logical concepts—but there is one study which appears to refute Piaget's results quite unequivocally. Estes reports that four (only) of Piaget's tests were administered to 52 Kentucky children ranging in age from four to six, and she comes to the conclusion that if children could count correctly, rearrangement of objects did not alter their reported

number, even with the four-year-olds. However, she omits to include a qualitative analysis of the children's replies, and since her apparent reduction of number understanding to counting is contrary to most (non-Piagetian) evidence, her results cannot be taken as being conclusive.

But for our purposes the real worth—or otherwise—of Piaget's psychology* is best seen in its paedogogical implications. Three things seem to follow from a consideration of the child at any of the Piagetian stages. Having found that a child is unable, say, to construct a one-one correspondence, we can say: (i) he is not yet *ready* to go on to more complicated mathematical operations such as adding, because (ii) they would have no *meaning* for him, and therefore it is likely that (iii) he will do poorly even in mechanical arithmetic—even though he may be trained to perform at a relatively high degree of speed and accuracy by dint of sheer drilling. This last, incidentally, is a good reason why mechanical tests of arithmetic are, by themselves, inadequate measures of ability to 'do' arithmetic. Fortunately, there is quite a considerable body of independent research evidence on each of these three points.

Some Educational Implications

1. *Arithmetic Readiness*

Piaget makes it quite clear that his children at ages four to six years do not possess the understanding of number sometimes attributed to them by their teachers. Verbal fluency with number words and ability to do rote counting do not allow us to conclude that the child knows what he is talking about. We have seen from the results of the brown and white beads test, that prior to stage three the child is largely incapable of appreciating the essential features of addition and subtraction. But this does not mean that one must wait until a chronological, or even a mental, age of seven-plus has been attained before teaching addition. Churchill's work demonstrates that, with appropriate teaching methods and number experiences, the requisite level of conceptual understanding can be developed as early as five to six years. The implication is rather that *until* this understanding is developed, at whatever age, it is a waste of time teaching such operations as $7 + 2 = 9$. Churchill would go even further than this. Premature arithmetic teaching, she says, may well be doing something more harmful than wasting time: it may set up barriers to the proper understanding of number when the child *is* ready. She suggests that this may be one of the causes of " the strong dislike and even fear that many intelligent adults have of mathematics."

Williams considers that the two main problems relating to early number readiness are that there is a lack of any readiness tests, i.e. tests of conceptual attainment, and that there is a need for a practical classroom programme to foster number thinking especially in those children who have poorly developed number concepts. He believes that the best approach to these problems is to be found in Piaget's psychology. Accordingly, he constructed two test batteries. The first consisted of representative tests from Piaget's own work; the second was a simple attainment test to relate computational ability to an apparent level of conceptual development. In comparing the results of these two tests,

*For a rather more detailed exposition of *The Child's Conception of Number* and a discussion of the educational implications, the reader is referred to a booklet published by the National Froebel Foundation: *Some Aspects of Piaget's work.*

he found that some children were able to compute accurately enough, but lacked any appreciation of the numbers concepts involved. Such children, on further investigation, were unable to make any but the simplest generalisations. It must remain, Williams concludes, a matter of conjecture as to what proportion of these subsequently become unhappy and insecure in relation to number activities.

He suggests a readiness programme, consisting of the basic process of ordination and cardination, which should assist the child in acquiring operational number concepts. When these are attained, and not before, the child is ready to proceed to more formal work. It is probably worth noting that in many other countries children do not begin school until six years of age, and in Sweden for example, where the age of commencement is as late as seven, teachers are forbidden to take mechanical arithmetic during the seven-plus year and may use only concrete apparatus. It is perhaps not so surprising, then, that the standards of such countries around the secondary transfer level are not noticeably inferior to our own—in spite of our apparent start of two years in learning arithmetic.

In an unpublished investigation conducted by the N.F.E.R., it was found that amongst thirty-eight primary schools studied, there was no significant correlation between amount of formal work attempted in the infant school and later success in the junior school as measured by mechanical and problem tests. In other words, those children who had covered a good deal of formal work (table-learning, manipulation of large sums, etc.) in the earliest stages evinced no tendency to be superior on later testings to children who covered a relatively less amount in the infant school.

Other relevant non-Piagetian evidence at this point may be found in the following studies. During the 1930's, the " Committee of Seven," under the chairmanship of Washburne, was set up to investigate the grade-placement of topics in the arithmetic curriculum in the United States. With teaching methods and time allocation controlled, each topic was introduced at three or four consecutive grades in a population of over 30,000 children in sixteen States. A battery of intelligence tests and ' foundation ' tests (to ascertain mastery of previous knowledge required for a given topic) was given. The topics were then treated in class. Finally, a battery of attainment tests was given to measure mastery and retention of the new topic. The minimum age at which 80 per cent. (or sometimes 75 per cent.) of the children had mastered each item was determined. Several of the results are of interest. It was found, firstly, that when tested at Grade VI, the best performances came from those who began formal arithmetic at Grade I (age 6+); next came those who began at Grade II (age 7+); and finally, those who commenced at Grade III (age 8+). However, and this is the interesting point, if a child did not begin formal arithmetic until Grade II or III and instead was given *informal* number activities and number games, his later performance was very much superior to the child who began formal arithmetic in Grade I. In any case, in terms of economic success, i.e. achievement in relation to the time spent in teaching, later placement was indicated. The Committee recommended that the addition facts with sums of 10 and under, and easy subtraction facts, should not be attempted before the mental age of seven to eight years; that is, well into the Junior level in our own schools! Up to this level, the curriculum should consist of " informal experience and activities to give children real concepts of number and space relations, without any systematic drills."

The validity of Washburne's findings can be challenged on many grounds. Curr, for instance, replicated the study as far as was possible in Scottish schools, but using only the teaching of division, and found that mental age *per se* was a misleading guide to placement. He came to the conclusion that a better prediction of future success could be made from the foundation test itself (mastery of prerequisite skills), or even better, from intelligence test results. Not having the same power to control teaching methods as Washburne, Curr found that there was a wide divergence in " optimum mental ages " for topic placement and that this seemed to be largely related to the techniques employed by individual teachers. Some teachers, that is, can teach the division process successfully at an earlier age than others—and there seems no valid reason to suppose that this would not be true of other branches of the subject. It would thus be wrong to accept the Washburne findings literally. Rigid adherence to them may hamper the efforts of the efficient teacher; and it would mask the effects of general improvements in teaching method.

There is, however, no dispute about Washburne's theoretical viewpoint; that " there is a point in a child's mental growth before which it is not effective to teach a given process in arithmetic, and after which that process can be taught reasonably effectively." The disagreement is in the precise determination of that point. It is clear that, although practical considerations such as school organisation and teaching techniques will bear on it, this is mainly a psychological problem. Placement and readiness studies will be only partially satisfactory if they are not rooted in child development and it is here that we find the relevance of Piaget's genetic approach.

Finally, it may be mentioned that on the matter of postponing formal number work, Brueckner, in a critical review of Washburne's and other relevant studies, states:

> " Strong evidence, therefore, leads one to conclude that formal work on number processes can be delayed until at least the second, even to the third grade, but that, if that is to be done, steps should be taken to develop in the first one or two grades a series of well-organized activities and units in social applications of number through which the child will be brought into contact with number in meaningful social situations in such a way as to insure more adequate readiness for the more formal work to follow."

2. *Teaching Methods: " Meaning Theory "*

The effect of psychological theorising on education can be clearly seen in the popularity from time to time of different approaches to the teaching of arithmetic. Basically, this has come down to mechanical versus meaningful teaching. The research results are also useful in interpreting the recommendations of Brueckner and Washburne concerning the postponement of formal work in the early years.

Up to the 1930's treatises on the teaching of arithmetic stressed an approach derived from the connectionistic, stimulus-response laws of behaviourist psychology. This consisted essentially of learning " bonds " between numbers. Hence, the theory ran, the more frequently the pupil practised drill, the more firmly " fixed " the number facts became in his mind. The technique was first to propound a general rule which was then learned by application to *n* examples.

About this time, however, the Gestalt school of psychology became popular and very different implications for teaching method resulted. The emphasis was upon " structured wholes " and the inter-relationship of parts to the whole. Applied to arithmetic, this implies that the understanding of number relations and of the total structure of arithmetic should be aimed at: an approach obviously more suited to problem solving than to drill—indeed, drill was deliberately neglected as being mechanistic and therefore inimical to the development of number meanings.

An approach sometimes confused with the meaning method is " social " arithmetic. This demands that the topics in arithmetic be limited to those which are found in adult usage—indeed, the extremists restrict this to child usage only. Thus, one would not give a pupil an example involving hundreds of pounds as it would be most unlikely that he would ever have handled such a sum. Studies of the use made by adults of arithmetic (e.g. Wilson and Dalrymple), have shown that in the area of fractions, 90 per cent. of business dealings and ordinary usage are covered by halves, thirds and quarters; the remaining 10 per cent. being covered by eighths, decimals and possibly twelfths. These and similar findings have resulted in the purging from textbooks of examples involving meaningless (to the child) LCM's of thirteenths, sevenths, etc., and have, indeed, led to much more realistic and meaningful examples and problems. However, it is obvious, in spite of the somewhat extravagant claims made for social arithmetic, that it is primarily concerned with the curriculum, although the problem-types suggested by social usage have been eagerly fastened upon by the meaning theorists. There is a definite link between the child's usage of a topic and the meaning that topic will have for him (see, for example, Brideoake and Groves' Birmingham experiment on infant number work) but this particular aspect of number meaning will be discussed later.

Although the controversy between the advocates of mechanical and meaningful teaching has been raging for about 25 years, as recently as 1957 Miller could point out that the relative superiority of the meaning method was as yet undetermined: and that " little research has been initiated to justify the great emphasis on the approach."

Nevertheless, one of the most impressive studies on the meaningful approach is that reported by Brownell and Moser. They obtained the co-operation of teachers in presenting four different ways of teaching subtraction, each teacher concentrating on one method. Using decomposition* and equal additions*, each was presented rationally (where the meaning of the place system was explained) and mechanically (where proficiency in learning a sequence of acts was emphasised). 1,400 Grade III children (approx. age 9) were used in the experiment. The results were evaluated not only by speed and accuracy but also according to degree of understanding, length of retention, transfer (i.e. the ability to transfer a set of rules or an understanding from one situation to another, where appropriate) and the value of crutches. Among their conclusions were the following: (i) decomposition taught rationally was the best method; (ii) equal-additions was hard to rationalise in terms the pupils understood, but equal additions

*Take the example : 134
69
65

In the decomposition method, one would say " 9 from 14 leaves 5; put down 5 and carry 1; 13 becomes 12; 6 from 12 leaves 6."

According to the equal-additions method, " 9 from 14 leaves 5; put down 5 and carry 1; 6 and 1 are 7; 7 from 13 leaves 6."
N.B. The wording of these illustrations is more in line with the mechanical approach.

taught mechanically obtained very speedy results—much more so than mechanical decomposition, or equal-additions-rational; (iii) Crutches were found to be helpful in decomposition especially, and could be discarded by the pupils without ill-effect when they were directed to do so by the teacher; (iv) generally, the rational approach led to much better retention over a period and to greater ability to transfer to new situations; while the mechanical procedure tended to be faster but less accurate—hence less economical ultimately. The success of the rational method will depend to a large extent on the degree to which any given topic can in fact be rationalised successfully in terms that children can grasp.

Anderson, using division, found that, overall, there was no appreciable difference between the two methods. On closer analysis of his results, however, it was found that for so-called " over-achievers " (i.e. those whose performance in arithmetic was better than might be expected from intelligence test results) drill was more effective; but with " under-achievers " (who would more likely be found in remedial classes under present selection methods) teaching which stressed generalisation and understanding was to be preferred.

Howard found that when fractions were taught by any of three methods (drill; meaning; meaning followed by drill), there was no *immediate* difference, but that after a period, retention tests showed a high loss for the first method, less for the second, and no loss at all for the third.

Both Thiele and Swenson found that children trained by the meaning method in learning the 100 addition facts were significantly more able to transfer this knowledge to arithmetic problems than those who had learned them by rote.

Miller, with a group of 600 children, went a stage further than those studies and investigated not one process, but all the processes involved in the elementary school curriculum, and in addition, employed a " Meaning Test " designed to evaluate the child's understanding of number concepts. His results are not entirely unequivocal, but he indicates that the meaning method is superior for dealing with fractions, decimals, percentages and " difficult concepts ", and also produces higher retention, especially with pupils of average and high ability. The rule method, on the other hand, appears to be more effective for immediate teaching of measurement, and generally for children of low intelligence.

On the other hand, Schonell recommends that children should attain automatic accuracy in the addition and subtraction facts—indeed, he advocates that addition tables should be learned by rote as should be the multiplication tables. Meddleton gave one group of children large amounts of systematically graded drill sums, so that all number combinations up to 100 were practised, with extra practice on combinations known to be difficult, and found that the children so drilled performed at a considerably higher level in both mechanical and problem arithmetic than those who had been given textbook sums to practise haphazardly. Thus, if used intelligently, even large amounts of drill need not be at all deleterious. But neither Schonell nor Meddleton would advocate drilling to the point of " automatic accuracy " as the means of *introducing* a topic.

Another finding of the N.F.E.R. study mentioned earlier was that where teachers in the fourth year of the junior school adopted a meaningful approach to their work, as

indicated by a positive reply to a question on whether they explained the " invert and multiply " rule in division of fractions or merely applied it mechanically, they obtained significantly better results in mechanical and problem arithmetic generally.

These results of a number of investigations, though not absolutely concordant, may lead us to certain valid conclusions:

1. If speed in a highly specialised task is the aim of teaching, the drill or mechanical method is likely to be superior: if, however, the children are required to transfer their knowledge and skill to new situations, the meaning method is much to be preferred.
2. Mechanical training may be more effective if the skill is required immediately after the training period, but if the skill is meant to be at all enduring, meaningful teaching is almost a *sine qua non.*
3. When dealing with more complicated material and more difficult concepts, the meaning method is essential. However, with children of low intelligence, the meaning method may be too difficult to apply: in which case (if the skill in question *must* be mastered) one would have to fall back on the rule method.
4. There is some evidence to the effect that children *like* to be taught meaningfully —although it must not be forgotten that the rote learning of material and the calculation of large numbers of drill sums can be source of pleasure to many children. The pleasure, however, soon palls if the child is continuously at a loss to understand what he is doing—even if he is getting his sums correct.

It seems, generally, that the most effective method is a combination of both—the topic should be introduced in a meaningful way, after which a reasonable amount of practice, or drill, is desirable to gain familiarity with the new skill or principle.

For the infant teacher, however, the question still remains: what is the best method of *introducing* arithmetic to children? The evidence seems to point to the meaning method, but we need to know *how* to explain something as basic as early number work, and guidance is necessary on the rather vexed question of the use to be made of concrete materials.

Prior to Piaget's work, there was little known about the logical properties of numbers *in relation to* the corresponding psychological development of number concepts. The problem of meaning could thus only be approached in a limited way. Either one analysed the logical aspect (*cf.* the " unit-skills " approach, as exemplified in Brueckner's early work) or, in the manner of the Washburne Committee, one obtained statistical surveys of the levels of skills at which children were capable of performing given operations, under given conditions of teaching. Neither approach offered much insight into the sequential and developmental aspects of number understanding and hence their applicability to teaching method, especially when we think of individual differences, is limited.

A sensible adaptation of Piaget's principles makes it possible, in the first and second years of school life, to provide the " rich number experiences " indubitably indicated by other research findings. If a proportion at least of these are of a " social " nature, so much the better. It must be stressed, however, that these experiences should cover the

areas of number operations which Piaget analysed, i.e. conservation-producing activities, matching, seriating, corresponding, additive- and multiplicative-compositions and so on. It is useless to prescribe such activity for a stated class or year level. The goal is " stage three understanding " whenever this may be attained. After this, the explanatory (meaningful) approach to specific topics—addition, division, etc.—is indicated. The proportion of drill will depend upon such things as the nature of the task, the intelligence of the pupil, the aim of introducing the topic and the desired length of retention.

Piaget explains the development of mental structure as involving, first, the activity of the child in his environment. This implies that children need much concrete experience in manipulating objects. Thus, school work which demands excessive abstraction before the child is ready will only puzzle and frustrate him. On the other hand, as this is only a *stage* in normal development, " spoon-feeding " by restricting the child to simple apparatus for too long may inhibit the development of the formal operational stage.

It is worth mentioning also that Van Engen, in an analysis of meaning in arithmetic, comes to the conclusion that action-experience is an essential prerequisite to the development of meaning. He derives the conclusion from a consideration of semantics and current meaning theory: meaning is acquired only when the symbol of an act is tied operationally, i.e. by " doing ", to that act or event. This theory springs almost entirely from logic; nevertheless, its educational implications, in this respect, closely parallel those following from Piaget's findings.

3. *The Place of Concrete Materials*

It was noted earlier (p. 19) that, contrary to some "progressive" views, indiscriminate enlivening of number work by means of concrete materials may actually be harmful to the development of number concepts. In the introductory chapters of her book, Stern subjects the whole question of the value of concrete materials to a searching analysis. Her point is that it is just as " abstract ", from the child's point of view, to present him with a picture of 4 bunnies and 3 bunnies (= ? bunnies), as to teach him by rote that $4 + 3 = 7$. What have *bunnies* to do with *units?* The important thing that the child has to learn is the relation between 4 and 3—which " bunny-learning " will tell him no more readily than rote learning. Churchill quotes a classic example of this sort of thing. She was visiting a classroom where the children were playing a fishing game. The fish were made of blue and pink card, each fish bearing a number. When a blue fish and a pink fish had been caught, the total score was to be added. Brian, aged five, caught a 3 and a 5, and when asked by the teacher how many he had caught, he replied, " two." This was not the " right " answer, as the teacher tried to explain.

In a recent survey conducted by the N.F.E.R., some incidental information about teachers' attitudes to concrete materials was obtained. There were great divergences in viewpoint—some maintained that concrete materials should be used only when essential; others that they baffle the child, that he should be introduced to the abstract nature of mathematics as soon as possible; while yet others regarded them as quite essential to arithmetic. Obviously, not all the teachers were thinking of quite the same thing, but there is, even so, a valid difference of opinion about their worth. This difference could well be due to a failure to make the distinction noted above between material which is

concrete, but essentially non-mathematical, and that which is a " concretising " of the properties of the number system. In this same study, a comparison was made between the school which employed a great deal of concrete material and those which used somewhat less. There was no significant difference in scores when the children were tested on mechanical problems arithmetic at each age level in the junior school. This result points to the conclusion that the use of concrete materials *per se* is not in itself advantageous: rather the use made of them seems to be the important thing. Ives reports that successful teaching of backward and emotionally disturbed children was most readily accomplished by material (Stern) which made concrete the structure of number: even very dull children could acquire certain ordinal and cardinal concepts which were simply not attainable by children taught with the more usual matchstick-counter types of material. On the other hand, Williams has noted that younger and more backward children may tend to use such material merely as an aid to computation, in as rigid and mechanical a manner as the counting of the traditional cowrie shells.

Further evidence that concrete materials may be abused is suggested in a study reported by Murray. She investigated the use of concrete materials in four Scottish infant schools, and found that when the children were tested during the first and second years in the junior school, those who had been introduced to arithmetic *via* the extensive use of concrete materials performed at a considerably *lower* level in mechanical, problem and mental arithmetic, than those who had been trained with little concrete material, the effects of intelligence having been partialled out.

On psychological grounds it is clear that the aim of number education is to procure understanding of the meaning of numbers and then to apply this to numerical processes, in mechanical and, later, problem form. Past practice in the infant school has possibly reversed this. By constant repetition of number processes the child, it is hoped, will gain understanding of number: a hope, it may be added, often realised in the case of very bright children. We should expect, then, that materials providing experiences which further numerical understanding should be of great value: those which simply put drill in a presumably more pleasant form are of more questionable help.

Of the former kind, there are first those suggested by the activities which are pre-requisite to number understanding—matching, seriating, etc. Churchill suggests many such activities in her thesis, as also does Williams in the article cited earlier. It may well be, too, that the success of " social " projects is not so much because they are adult situations in miniature, although they would appeal to children for this reason, but because shopping, for example, gives experiences of one-one correspondence (one penny for one sweet); both weighing and measuring emphasise conservation, the constancy of the unit and cardination proper; and so on. Other valuable activities and materials can easily be devised by the teacher. The important thing is to provide equal opportunities for the often neglected ordinal aspects of number, as well as the purely cardinal, to develop.

It is interesting to note that Gunderson gave seven-year-old children, who had not been specifically taught multiplication and division, some problems involving both these processes. She found that when they fully understood the processes of addition and subtraction, they could, with the aid of concrete and semi-concrete materials (counters and diagrams), generalise to the more complicated processes of multiplication and division

without any help from the teacher. Two things should be noted here: (i) if the children had been taught addition and subtraction by a mechanical method of following rules, they would not have been able to solve the test problems, and (ii) it is unlikely that they all could have performed this feat of generalisation without being tied to reality, as it were, by the materials provided—although a few of the brightest children were able to solve the problems mentally.

There are more elaborate materials which attempt to represent the actual *structure* of the number system. The basic idea behind these is that the child, by manipulating rods or blocks in a systematic and controlled way, will discover for himself (under a certain amount of guidance, of course) the meanings of number relations and number concepts generally. The two most popular of such methods are probably those devised respectively by Stern and Cuisenaire, in each of which both counting and measuring—ordination and cardination—are systematically employed. The major purpose of this type of material is to develop initial understanding of relatively simple but basic concepts, although it is also claimed that their use at later stages in the junior school provides the conceptual foundations for such topics as directed numbers, manipulation of unknowns, and so forth, in secondary mathematics.

In Piagetian terms, one could say, firstly, that by manipulating the material himself, the child is gaining action-experience out of which operational concepts may develop; and secondly, this mode of presentation is in keeping with his conceptual level since the pre-adolescent is not capable of true formal abstractions. Thus, his perception of number operations symbolically structured by blocks helps him to grasp the particular concepts so represented.*

There has, however, been very little research reported to date where the effectiveness of such material has been unequivocally demonstrated: the N.F.E.R. is aware of this *lacuna* and is initiating a large-scale investigation to determine what actual, practical value they might have. Such work as is reported, however, seems to bear out theoretical expectations. J. Miller, for instance, taught the 42 children in her experimental group throughout Grade II by the Stern method, while a control class of 45 children, with the same amount of teaching (½ hour each day) and using the same syllabus, were taught by traditional methods. By the end of the year the experimental group had surpassed the controls in all portions of the curriculum, including purely factual knowledge, and especially where understanding of the number system is involved, e.g. place value and problem work.

These findings are highly suggestive, but the scope of the study is too restricted to make valid generalisations permissible. Karatzinas and Renshaw sent a questionnaire to forty teachers who had started at Primary I level to use the Cuisenaire material in Edinburgh schools. While some were reluctant to commit themselves after only one year's experience with the material, the majority considered that they were achieving comparatively better results, that skill in the four rules was more quickly and easily developed, and that the children found the rods more attractive than more usual types of counter apparatus. In addition to this survey, a group of forty children who had had eighteen months of experience with the material were matched with a control group of

*It is no mere verbal accident that we talk of "seeing" a problem as of seeing an object.

thirty-eight children who had been taught by traditional methods. When a simple fractions tests and sections of the Schnonell Diagnostic Arithmetic Test were administered, it was found that in the sub-tests completed by both groups there were no significant differences in scores, i.e. the experimental group had gained a no less effective mastery than the control group. However, the control group had not made sufficient progress to be able to attempt the multiplication, division and fraction items, whereas the children taught by the Cuisennaire method could solve these items quite easily. As with the Miller's study, these results are certainly promising but stand in need of confirmation from studies performed on a wider scale.

In conclusion, it should be added that when it comes to the practical question which faces the teacher—what methods or techniques ought I to employ?—the answer is by no means as clear as statistical results, even when backed up by respectable theory, might indicate. It is a truism to say that teaching is large a matter of personalities and personal relationships. There is little doubt that a poor teacher, using a very " good " method, i.e. one which has proved successful in a controlled experiment, will obtain worse results than an excellent teacher using " inferior " techniques. Further, the demands of a " good " method may not be suited to a particular temperament; some teachers may well do better, and feel happier, with a " poorer " method. This, for instance, may go a long way towards explaining the results of Murray's study. There has been very little research into the question of teacher personality, very largely because it is a most difficult matter to investigate—in this country, especially.

The best research can do is to point out the effects that certain methods and techniques have had when used under controlled conditions. Where the outcomes coincide with the teacher's aims, and where these conditions approximate to the teacher's own, he has reason to give the findings his most serious consideration.

Conclusions

Consideration of the findings of Piaget and other research workers has led to several conclusions which seem to be of importance to the teacher.

1. The immediate goal of early number teaching, prior to the introduction of formal work, is seen to be " stage three understanding ".
2. This may be attained by means of appropriate number games and experiences involving mathematically sound concrete materials, i.e. those which take both ordination and cardination into account, as early as 5 or 6 years.
3. It would appear to be advantageous to substitute such a programme of number experiences for much of the formal work which is currently performed in infant schools.
4. Psychological theory suggests, and empirical evidence confirms, that meaningful and explanatory teaching in the junior school produces results more consistent with the basic aims of number teaching. Mechanical drill, however, may be valuable when applied systematically to material which has already been introduced meaningfully.

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CLASS SIZE AS A VARIABLE IN THE TEACHING SITUATION

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Introductory

THIS is a matter of perennial interest. The teaching situation (as thought of in connection with formal schooling) involves a relationship between adults and children. Is the size of the group significant? Should every pupil have the undivided attention of a teacher? Can equal benefits or greater benefits come from the assembling of several children (or many children) under the direct guidance of one adult?

The question invites consideration of educational purposes. Its answering must obviously be determined also by the resources available—whether financial, material or personal. It is, therefore, not surprising that treatment of the topic has passed through a number of phases, varying to some extent with economic conditions in different centuries and in different countries and closely related to the prevailing undertones of contemporary educational discussion. Like many other areas of educational research, the field was first entered by the philosophers. They directed attention to some of the ideals of effective learning and offered certain suggestions. Echoes of their arguments still linger in our ears; but a clear progression can be traced in the last few decades from such theoretic discussion, through early efforts by psychologists who used the methods of what was then called ' experimental education ', to controlled comparisons with the use of objective tests, to more skilled analysis of test results and, more recently, to fuller recognition of the complexity of the teaching situation and the part played in it by attitudes and relationships.

I. Philosophic Discussion

Lively disagreements are the chief characteristic of the theoretical approach. These range from Comenius' plea for the assembling of large numbers in schools to Locke's distrust of every form of public schooling.

" I maintain," said Comenius, " that it is not only possible for one teacher to teach several hundred scholars at once, but that it is also essential; since for both the teachers and their pupils it is by far the most advantageous system. The larger the number of pupils that he sees before him the greater the interest the teacher will take in his work . . .; and the keener the teacher himself, the greater the enthusiasm that his pupils will display. To the scholars, in the same way, the presence of a number of companions will be productive not only of utility but also of enjoyment (for it gives pleasure to all to have companions in their labours); since they will mutually stimulate and assist one another."

As if in direct reply to this came the rejoinder of John Locke: " Let the master's industry and skill be never so great, it is impossible he should have fifty or an hundred scholars under his eye any longer than they are in school together; nor can it be expected that he should instruct them successfully in anything but their books. . . . Till you can find a school wherein it is possible for the master to look after the manners of his scholars . . . forming their minds to virtue . . . you have a strange value for words when, preferring the languages of the ancient Greeks and Romans to that which made them such brave men, you think it worth while to hazard your son's innocence and virtue for a little Greek and Latin."

Similar diversity of viewpoint is to be found in the 1945 challenge by W. C. Bagley to Carl Seashore's plea for the economic use of inspired teachers and for the encouragement of self-help through larger classes than were then customary. Arguments in favour of large numbers of pupils under the care of one teacher are no longer supported (as they were in the pages of Comenius) by the plea that such classes are the only conceivable means by which the benefits of education can be made available to all pupils irrespective of their prosperity or sex. It is now, in most parts of the world, an accepted tradition that for primary and secondary education groups will be considerably below one hundred in size and that teachers must be found and buildings provided in numbers sufficient to make classes of much less than fifty the rule rather than the exception.*

The connotation of the word ' large ' has thus insensibly altered; and the discussion has widened to include as arguments in support of large classes not only the economical use of buildings, and the reduction in the number of teachers required, but the socialising and democratising opportunities provided by larger groups and the encouragement which they can give to independent study; while on the other hand the plea for small classes now presents the claim that a reduction in size will be followed not only by higher achievement, but by more regular attendance and better behaviour on the part of pupils along with improved morale among teachers.

Opinions of Teachers and Pupils

Much of this discussion comes from parents, administrators, or philosophic observers of the educational scene. Not dissimilar diversity of viewpoint is, however, reported in the smaller number of published statements which proffer a record of the collected comments of teachers and pupils. Teachers on the whole appear to believe that large classes are exhausting, a cause of frustration, and a reason for failure in basic subjects such as reading or arithmetic. In contradiction to this, some find larger classes more interesting and stimulating; and pupils have recorded the view that a greater variety of opinions can be obtained in large classes and that larger classes foster more self-reliance.

When specific statements are invited there is some tendency for preferences to be shown for the size of class to which pupils have become accustomed and in which teachers have experienced success. Over the decades there has been, for example, a gradual reduction in the numbers described as ' large ' and this has run roughly parallel with the lowering of authorised and of actual enrolments in schools in Western Europe and in the

*The study of the reasons for this change in viewpoint fall in the field of the history of education and no attempt is made to deal with them here.

United States of America. In 1929, for example, a consensus of opinion among teachers (the majority of whom had classes of over forty) was expressed in favour of groups of not more than thirty-five to forty, while in 1939 the number considered desirable was of the order of thirty. By 1949 (when the median was nearer to thirty) many teachers agreed that though groups of eleven to thirteen were too small for efficient instruction, and groups of thirty-two or thirty-three were too large, the ideal might usefully be set at about five-and-twenty. (Not quite irrelevant to this is a careful study of sub-groups of different sizes within a larger class in which it was reported that greater enthusiasm for work with small groups was found among the more inexperienced teachers and among students highly concerned with their own fears and anxieties while non-authoritarian instructors of fuller experience set more value on the intellectual stimulation of the larger groups.)

Connotation of the Term ' Class '

A further complication in all such argumentation has been the varying connotation of the term ' class '. This may be defined as the number of pupils who regularly meet in one ' administrative and instructional unit—usually under the direct guidance of a single teacher '; and in most reports the word undoubtedly carries this meaning. Where surveys have been extensive there is, however, no reason to doubt the inclusion of certain single-teacher schools and it is rarely indicated whether the word ' class ' is then taken to refer to the number of pupils under the exclusive supervision of one adult or to the number of pupils of a particular grade or age-group within the larger unit of the school.

The significance of the term also varies with accepted practice in larger schools at different stages in the educational process. At the primary stage it is quite customary for a ' class ' to be a group of pupils under the charge of one adult for all or most of the subjects of the infant or the junior school, while at the secondary stage some degree of specialising is usual; and at the tertiary or University stage teachers do not accept responsibility for work in more than one field.

This difference in itself has probably some bearing on the attitude of teachers towards groups of varying sizes; and it may account for the fact that University teachers have tended to be less vocal on the issue of class size than their colleagues whose work lies with younger children. Differences in the degree of specialisation have also tended to be followed by greater variations as between the burdens of one teacher and those of another at the secondary and the tertiary stages where selection of subjects and courses is commonly followed by marked differences in the sizes of the groups electing to take subjects such as music, art, classics, or science in contrast to groups following prescribed courses in certain other subjects.

Teaching Load

As a development of these discussions there has come a gradual realisation of the complexity of the administrative issues involved in both planning and furnishing buildings in which teaching is to take place. In a classroom of a given size a group of little children requires less space than does the same number of adolescents or of adults. Their output in written exercises is also less voluminous and appears to be less exacting from the point

of view of the time required for its marking. For reasons such as these it has often been assumed that classes at the primary stage may justifiably be larger than classes at the secondary stage.

At the same time certain changes have taken place in interpretation of the teaching process, and at all levels there is now more doubt as to the effectiveness of the teacher who, as an instructor or lecturer attempts all the time to command the attention of all beholders. " When I do ope my lips let no dog bark," is no longer supposed to be a typical expression of a teacher's point of view and the dreams entertained in the 1890's by Search, Rice and others as to the possibility of more active co-operation in learning on the part of pupils have been followed by the administrative proposals of the 1930's and the new buildings of the late 1940's and the 1950's.

Associated with this is the fact that many arguments about the significance of class-size have themselves been contributory to a more realistic awareness of the nature of a teacher's ' load '. It is now, for example, frequently admitted that this includes not merely the number of pupils in a class but all the activities which are related either directly or indirectly to a teacher's professional duties, responsibilities and interests. Account is, therefore, beginning to be taken of such differences as the character of the subject to be taught, the number of class-periods of instruction per week, the extent of duplication in the preparation of lessons for different classes, the length of teaching periods, the time spent on extra-curricular activities, the extent of overcrowding in classrooms, the amount of secretarial work required, the adequacy of the teaching materials provided, and the total number of pupils with whom the teacher has to make contact. All these are variables in the teaching situation from an administrative point of view; and to an increasing extent argumentation is turning to them in contrast to an earlier preoccupation with the issue of class size.

II. Research Studies

A somewhat similar increase in subtlety of interpretation—though in a different direction—may be seen in the course taken by educational research over the same decades. The nature of the conclusions reached by fully reported research studies on the matter of class size is, however, in marked contrast to the trends of opinion characteristic of the more theoretic approach. Most investigators started from the presupposition that size of class would prove a significant determinant of the degree of success achieved by a teacher. There have been many investigations; but, with few exceptions, it has had to be reported that, under typical conditions, class-size in itself appears to be an unimportant factor. The benefits of small classes, though commonly taken for granted by theorists, are as yet largely undemonstrated in the pages of accredited research reports.

This conclusion has been reached at every level from infant-room to University lecture-theatre. It has been formulated in relation to many subjects; and it is supported both by test results and by assessments of various types.

Available evidence is difficult to interpret—in the first place because of the diversity of opinion as to what constitutes a ' large ' group and what should be described as a ' small ' one. Methods of reporting research findings also range from incidental mention in the analysis of responses obtained for other purposes to deliberately-designed experiments with the use of the most modern statistical techniques in the treatment of results.

Early Psychological Studies

The first investigation which can be said to fall within the field of educational research seems to have been one carried out by Rice in 1902 as part of his enquiry into the reasons for the wide differences among pupils to which attention was then beginning to be given. Using specially-devised group tests of arithmetic he sought to relate variations in the responses of some six thousand children in grades four to eight (ages approximately 10 to 14) to differences in the size of the class, the number of minutes given to the teaching of arithmetic each day, the method employed, the age of the pupils and the nature of the home environment. The conclusion reached in each case was that, contrary to expectation, there was a lack of direct relationship between success and each of the concomitants examined.

It is a matter for regret that in the case of class-size, Rice did not publish details of the scores obtained; but his conclusion is quite unequivocal. "The number of pupils per class was larger in the highest six schools than it was in the schools of City VI (next to the lowest in average achievement) and the classes were exceptionally small in the school that stands at the lower end."

In a repetition of the same experiment in 1903, using a test of language instead of tests of arithmetic, Rice reached the same conclusion. "It has always been supposed that the size of the class must necessarily exert a powerful influence on the results. But investigation showed that there was no relation between the size of class and the results, that some of the best work had been done in the largest classes, and some of the poorest in the smallest classes." These findings attracted considerable attention and the topic of size of class took its place among other contemporary studies of the reasons for scholastic success and failure.

The most productive period from the point of view of research appears to have been the years after the first world war—the 1920's and the early 1930's. Butsch, for example, writing in 1934 mentioned two hundred and five references to one hundred and eight studies cited by Irwin in the years from 1900 to 1932, while Otto and von Borgersrode, in 1941, reported a total of two hundred and sixty-seven studies which it was then possible to trace. Not all of these documents are now accessible and in some instances it is probable that the differences between groups of different sizes were so small as to fall within the limits of those which might have occurred by chance.

Illustrative of a careful early study is one carried out by Dawe in nine schools in Minnesota with four hundred and thirty-three kindergarten pupils arranged in seventeen groups varying in size from fourteen to forty-six. Their recollection of a story which had been read to them was tested by questions on the following day; but no demonstrable differences were discovered either in relation to the size of the group or to the sitting position of the pupils in relation to the teacher. A further study with the same number and size of groups but involving group discussion showed, however, a difference in favour of the smaller groups in the percentage of pupils taking part in the discussion, the number of children who spoke and the number of remarks per child. There was no attempt to estimate the significance of these differences; but the children in the larger groups appeared to have had fewer opportunities for conversation although the amount they learned in a more formal lesson had not been affected.

A contemporary enquiry by Miller into efficiency of instruction in High School Physics showed a similar absence of any appreciable effect on learning among much older pupils with groups varying in size from three to thirty-one. (In this, again, no information was given from which the significance of any differences could be calculated.)

More adequately controlled experiments with the use of objective tests are reported in surveys of research studies in the early 1930's; but in many cases in these also no attempt was made to report findings except in terms of percentages or averages—without fuller statistical treatment of the results.

A summary of the recorded conclusions of the less accessible of these earlier studies may be of some interest.

Table I

A SUMMARY OF STUDIES ON CLASS SIZE

Numbers in Classes		Stage	Author and Date	Differences		Subject
Large	Small			Significance reported	Significance not reported	
44	20 34	Secondary School	Tope, 1924		Medium & small groups slightly better	English
104	36	College	Taylor, 1929		No difference	Psychology
44	23	High School	McGuire & Hudelson, 1930		Mediocre pupils did better in large class	Plane Geometry
70	35	High School	Davis & Goldizen, 1930		Small advantage to large class.	History
51	20 or 21	High School	Smith, 1930		Small class superior in letter writing. Large in reading, etc.	English
80	20		Brooks, 1930	No difference		English Composition
55	30	High School	Bloomfield, 1930	No difference		History
105	27 and 45	College	Beauchamp, 1930		No difference	Education
336 (*largest*)	8 (*smallest*)	College	Hudelson, 1930, 1932	Large superior in 50 per cent. of experiments. Small superior in 5 per cent. of experiments.		140 experiments with groups of differing size.
150	36 and 40	College	Remmers, 1931		Large slightly better	Psychology

Table I—A SUMMARY OF STUDIES ON CLASS SIZE—*continued*.

Numbers in Classes		Stage	Author and Date	Differences		Subject
Large	Small			Significance reported	Significance not reported	
40	20	Grades I to IV	Whitney & Willey 1932		6 per cent. in favour of small class	
42 38	27 20	High School	Holy, 1932	No difference		English
100	35	College	Raths, 1933		No difference	Biology
150	40	Grade VI	Stoddard, 1934		Large gained more	Science and Music with Sound Pictures
105	22 25	College	Hand and Smith, 1934	No difference		Business Training
39	11	High School	Dalthorp, 1934		No difference	English Composition
Over 35	Less than 25	High School	Baker, 1936	Knowledge of pupils slightly better in small		English, etc.
More than 30	Less than 25	Primary	Newell, 1943	Teachers of small classes more inventive and more willing to try new practices.		

More Skilled Analysis of Test Results

Illustrative of the difficulty of arranging controlled experiments is a study by Jensen in which one hundred and eighty-five boys and girls were arranged in groups of from ten to seventeen (the small classes) and from forty to forty-eight (the large classes). The pupils were paired on age, on an intelligence test and on a test in algebra. They were then taught for a semester by teachers who each used the methods they themselves preferred. Retesting at the end of that time, while it showed similar mean gains in all groups, indicated also more significant differences in the smaller groups and a small mean superiority of those in the small classes over their peers in the large classes. These differences were, however, so small as to fall within the limits of those which might have occurred by chance; and it is worthy of note that the pupils knew the purpose of the testing and that rivalry between large and small classes was keen throughout. Something more than merely the effect of size obviously formed part of the experimental situation on this occasion.

A recent study of a different type is that of Spitzer in which, using nearly two thousand pupils in grade III and over seventeen hundred pupils in grade VI, a series of comparisons

(with calculation of the significance of the differences of means) was made between one hundred and five classes whose average size was about twenty-two (the small classes) and forty-three classes of thirty pupils or more (the large classes). The tests employed were the Iowa standardised tests of reading, language skills and arithmetic skills and the classes tested were deliberately selected from both large and small cities in such a way that it could not be said that the larger classes were predominantly in the larger places which might perhaps have attracted the more capable teachers and whose level in equipment, buildings and supervision might have been higher.

After extensive analysis of test results it had to be reported in this series also that no significant differences were found as between the two sizes of groups although slightly lower scores were made by the smaller groups in language skills and slightly higher scores in arithmetic and reading at approximately age nine along with slightly higher scores in arithmetic by the larger groups at about the age of twelve.

Findings Incidental to Other Enquiries

Not dissimilar findings are recorded as incidental to another study in Maxwell's report on the 1947 Scottish Mental Survey in which a test of general mental ability had been given to all pupils aged eleven years. The size of the class was in this case defined as the " ratio of pupils on the roll to the number of teachers "; and in general it was found that while children with the highest average test scores (38.09) appeared in the very small schools with fewer than twenty pupils and in the very large ones with more than nine hundred pupils (37.97), the highest average test score, when classes of different sizes were considered, was that of pupils in classes of ten to nineteen children (38.11). Next in order to this came the averages 37.21, 36.46, 36.32 and 36.12 in classes of sizes twenty to twenty-nine, one to nine, thirty to thirty-nine, and forty to forty-nine respectively. The significance of these differences was not reported; but it was added that although a few schools with a ratio of more than fifty pupils per teacher were recorded for the cities there was no indication that these pupils were significantly better or worse than the others in test scores. There was also no apparent relation between test score and the number of schools previously attended.

This evidence as to the superior scores made by pupils in the very small schools in the more remote rural areas may be compared with the findings of another report from the Scottish Council for Research in Education on the testing of pupils of average age twelve and three months in some two thousand four hundred schools (Mowat). In this study the highest average quotients in tests of Intelligence, of English and of Arithmetic were obtained either by schools presenting fewer than ten pupils for admission to secondary schools (those in Arithmetic) or by schools presenting more than thirty pupils (those in Intelligence and English). The differences between these and the scores of pupils in schools of medium size were large enough to be significant. Information is not here available as to the exact size of class in each case; but in the circumstances of the testing it was known that the schools presenting fewer than ten candidates were for the most part the small schools in rural areas while those presenting more than thirty were schools with large classes in urban areas.

More relevant to the question of the direct differences associated with size of class was material recently obtained* by the National Foundation for Educational Research in England and Wales from a sample of more than four thousand pupils aged eight years. Using tests of mechanical reading ability (fifty words) and a picture ' intelligence ' test, a comparison was made of results in classes of less than twenty with those in classes of more than twenty pupils on the grounds of the higher average scores made in the Reading test by pupils in classes of two to nineteen (53.33) as compared with those in classes of twenty to twenty-nine (51.70), thirty to thirty-nine (50.33), forty to forty-nine (51.28) and fifty to fifty-eight (50.75). Analysis of variance indicated a significant relationship between the superiority of small classes and the type of school attended. When, however, a more detailed comparison was made as between one size of class and another, analysis of variance suggested that there was not, overall, any significant difference between the average performances of pupils in classes of various sizes in these two tests.† This is associated with the figures obtained for classes of forty to forty-nine and those of classes of thirty to thirty-nine where the difference was significantly in favour of the larger classes.

A further inquiry into reading ability in a sample of fifty-one primary schools in Kent provided evidence as to the results of tests of reading-comprehension and (non-verbal) mental ability administered to rather more than seven thousand pupils of ages seven to eleven (Morris). Good reading attainment was found to be to some extent significantly associated with large schools, superior school buildings, urban areas, deliberate and early tuition in phonics and classes with an unfavourable pupil-teacher ratio (large classes).

Not dissimilar findings came from an investigation of much smaller scope in which in information collected in brief visits to fifty schools there was some indication of little relationship between level of attainment, class-size and informal methods (Kemp). The last two variables were also studied in a year's experiment in the teaching of reading by a phonic-word method (Daniels and Diack). In this the experimental class of forty-four non-readers was contrasted with three control groups of twenty-five, twenty and ten pupils of similar reading ability and similar home background. At the end of the year significant superiority was shown by the larger class along with greater independence of attack on the part of its pupils.

Another type of indirect approach to the same problem of class-size is represented by a study of Lundberg in which a reduction in class-size from thirty-seven pupils to thirty pupils was (in a comparison with past records in the same school and in relation to national norms on the tests used) estimated to have led to an improvement in achievement, in attendance, in behaviour and in morale. This may usefully be contrasted with an extensive comparison of scores in standardised achievement tests of ability and personality administered in a city in Southern California (average size of class in Grade III: 29.5) and in British Columbia (average size: 38). In both cities scores were well above national norms but those from British Columbia compared favourably with those from

*Pidgeon, D. A. : Data on Class Size obtained from the Population Investigation Committee Survey (personal communication).

†Penfold, D. M. E. Personal Communication.

South California (Wilson). The significance of the differences was not, however, indicated in either of these studies.

Once again, therefore, it has to be said in the light of such incidental enquiries that class-size in itself does not appear to be a significant factor in achievement; and further support is lent to the earlier generalisations of Rice, Butsch, Otto and von Borgersrode that the secret of the difference between the success of one teacher and another must be looked for in something other than the mere size of the group under tuition.

Fuller Recognition of the Complexity of the Teaching Situation

Attempts to take account of other complexities in the teaching situation may be illustrated from Eastburn's extensive experiments with three hundred and sixty eleventh grade pupils arranged as one class of sixty and two classes of thirty at each of three ability levels in English and History (the size of the groups being reversed for the two subjects). These boys and girls of about the age of sixteen were initially matched by age and sex on a test of mental ability, on objective tests, and on their teacher's ratings. Each teacher took both large and small classes and followed the same type of teaching programme with each. At the end of a year, re-testing showed that the average scores of small classes on objective tests did not differ significantly from those of large classes in either English or History on the lower level and the upper level or in History on the middle level; but scores were significantly higher in the larger classes in English at the middle level of ability. A test of attitude given to all the classes showed no significant differences, and among the teachers who had taken part in the experiment there was no unanimity of opinion in their agreement with a list of the arguments commonly offered for and against large classes. Class size had no appreciable effect on disciplinary problems at any of the three ability levels; and the amount of inattention observed bore no relation to the size of the class.

In a second experimental study a year later, it was arranged that the same three teachers (with the aid of a secretary shared amongst them) should each take five classes of fifty pupils for English. The pupils were matched with pupils in the large and small classes of the previous experiment; and the findings again threw doubt on the assumption that pupils of lower ability should necessarily be taught in smaller groups than those of middle or upper ability. In the case of one teacher the learning of the five large classes was not significantly different from that of the groups of thirty in the previous year. With the second teacher the large classes did significantly better than the small classes at the middle level and equally well at the upper and lower level. In the case of the third teacher there was not a significant difference in achievement.

A somewhat similar enquiry by Cammarosano with young undergraduates in the field of the Social Sciences also contrasted groups of sixty with groups of thirty and showed comparable care in initial matching and in the covering of the same syllabus by the same professors over a full academic year. The results for tests for ' command of subject matter ' and for ' interest in public events ' showed no significant differences in mean scores in large and small groups; but in a test designed to estimate skill in applying prin-

ciples the students from small classes in Sociology did significantly better than those from large ones while the size of the group did not significantly affect the response of the students taking Economics or Political Theory. In extensive interviews in which an attempt was made to discover the opinions of the students on such matters as vision, hearing, ventilation, opportunities for questions, discussion and consultation, the large groups appeared to have been as satisfactory as the small except for some complaints as to overcrowding. The teachers, on interview, expressed awareness of greater effort in establishing informality with large groups, in enlisting participation in discussion and in discovering special difficulties among students (because of the presence of an assistant taking the attendance) but they estimated that the time for marking papers, etc., was approximately twenty-five per cent. less for one class of sixty than for two classes of thirty.

In another study with nearly two thousand somewhat more senior University students, Husband compared the efficacy of lecture groups of one hundred and eighty to three hundred students as compared with smaller sections of thirty to sixty in the field of General Psychology. Again, the conclusion had to be that measurable differences were not statistically significant; and that the impersonality of the larger group did not lessen either the liveliness of questioning or the will to learn on the part of the larger groups; nor did it result in discernible gaps in their knowledge.

Research in Progress

Willingness to experiment not only with differences of size of groups but with differences in the use of non-teaching assistants is a feature of an important long-term study recently initiated in Jefferson County, Colorado. This, as reported by Patterson and by Romine, is interesting in that it proposes over a period of five years to study not only variations as between groups of ten, twenty, thirty-five, sixty and seventy High School pupils in different subjects, but also a variety of combinations of teams of teachers with and without clerical assistance. By this means it is hoped to test the hypotheses that in certain learning situations the number of learners is insignificant, that differing techniques are suitable for groups of different sizes, that when certain techniques are used the learning situation is unaffected by building facilities, that the morale of teachers working in teams with large groups is higher than that of those who work in isolation with small groups and that the problem of the shortage of qualified trained teachers can be met by the provision of non-teaching assistants.

Comparable concern with teaching techniques as well as with differences in measurable attainment is characteristic of a study in which in relation to the teaching of geometrical drawing in the first year of a secondary school two groups of seventeen (the small classes) and two groups of thirty-four pupils (the large classes) were compared. All four groups were matched for general mental ability and for age. The teacher, the classroom, the syllabus, the equipment and the time were the same for all; but one large group and one small group were seated according to their sociometric choices and in the other two groups no account was taken of the pupils' preferences and friendships. At the end of three terms, standardized tests showed no significant differences in attainment according to the size of the groups (using analysis of variance) but there were significant differences

in the means in favour of the sociometrically-seated groups not only when each group was compared with another of the same size, but when the large sociometric group was considered against the small non-sociometric group.

III. Other Contrasting Fields of Educational Enquiry

In contrast to all this scarcity of evidence that class-size is in itself significant, mention may at this point be made of the findings which have accumulated in recent years as to the differences consequent on different types of climate in the teaching situation. Changes in this are known to have been effected without change in the number of pupils under instruction. They have been recorded at the primary level (Shimeld and Waite) and at the secondary level (Rowe) and in both controlled and uncontrolled situations.

Pupils respond differently to different teachers. The quality of their learning varies with the different approaches which can be used by the same teacher. It is modified also by changes in the type of school organization (streaming or non-streaming). It is altered by the encouragement of more spontaneous participation in group activities (competition or co-operation). It is transformed by changes in the self-picture of the pupils (by increases in their self-confidence and self-respect).

The differences to which attention requires to be paid from the point of view of those aware of the findings of educational research can therefore now with some assurance be said to include more than the externals supplied by administrative enterprise in the allocation of teaching load, size of class, time available and the like. The subtleties of inter-personal relationships have also a part to play. A school in which participation and co-operation is encouraged on the part of the staff is more likely to be one in which both teachers and pupils will develop high morale. A classroom in which a teacher permits opportunities for independent learning through co-operative activities (with provision of material for some measure of self-instruction and self-correction) is more likely to see the development of wholesome self-pictures and increasing ability to learn on the part of its pupils.

This does not mean that class-size is a matter of no importance. It serves rather as a reminder of the complexity of the teaching situation and of the supreme significance of the quality and the skill of the human being in charge of that situation. The size of classes has, with general approval, been reduced by law over the last sixty years; and discussion now centres on groups in the thirties and the forties, rather than the nineties or the hundreds. The protest of teachers against ' large ' classes has been observably most vocal in periods of expanding enrolment—the 1920's and early 1930's, the late 1940's and again in recent months when the ' bulge ' in birth rate is beginning to affect the secondary schools. This protest is not to be disregarded. It merits attention in terms of the effect of a larger group upon the teacher's load—of overcrowding, of lack of equipment, and of inadequacy of secretarial help in the cyclostyling of material and in the keeping of records. In interpretation of the general trend of theoretical discussion, public opinion, and research evidence over recent decades, it can, however, be said that there is no justification for supposing that a small class under the charge of an imperfectly educated adult is preferable to a larger class with a skilled teacher in command. In times of shortage of

teachers or inadequacy of buildings, the mere addition of more adult ' bodies ' to function as ' teachers ' with smaller groups appears, therefore, to be less wise than attention to improved morale among skilled teachers through other use of auxiliary manpower along with more generous provision of teaching aids designed for the encouragement of active individual co-operation of pupils busily employed in the furthering of their own education.

Rice was feeling his way towards this when, in discussing scientific management in education, he dared to report the apparent irrelevance of size of class, duration of lesson and method of teaching employed. Scientific management in schools is now known to involve as a priority the establishment of satisfactory relationships—of a situation in which pupils and teachers are aware that in some sense they are appreciated, that some measure of success is available to them and that they have some understanding of the meaning of the activities in which they are asked to co-operate. Good buildings and space for working—the size of the most immediate group—are indirectly contributory to this as indicative of respect and appreciation from the more remote and impersonal ' organizers ' of institutional life. As only one of the variables in the teaching situation they cannot of themselves ensure that conditions within the classroom will necessarily be contributory to learning. In this there probably lies one of the reasons why, in the light of educational research, it has not proved possible to confirm the hypothesis that size in itself is a definitive issue.

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URBAN & RURAL DIFFERENCES IN ABILITY & ATTAINMENT

by F. Barr

Introduction

IT is alleged sometimes, that children from the rural areas are on the average both educationally and intellectually inferior to their urban contemporaries. Often it is argued that this may be due to a general all-round inferiority of the rural population in educable capacity brought about by such causes as an unstimulating environment or a migration of the abler families to the towns. Alternatively, it has been stated that the rural schools, for reasons of size, equipment, and the training or experience of their staff cannot do as well for their pupils as the larger schools in the towns.

Such hypotheses have led to a number of suggested lines of action. For example, it has been argued that a higher or at least an equal proportion of grammar school places should be granted to children from rural schools as are given to urban pupils, irrespective of ' ability ' as measured by tests. It has also been suggested that the teaching methods of the rural school should be changed to take account of a different kind of human ability and that rural and urban groups need separate treatment. Indeed, speculation has been more rife in proportion to the conflicting nature of the evidence than to its absence.

It is evidently important that administrators who have to decide on the amount and kind of educational provision which should be made in town and country and teachers who have to deal with children from rural or urban areas should have a clear idea of the facts. Even more important, in many ways, if such differences in ability and educational attainment do exist is it to know the nature of other differences which may be associated with them and their likely causes. Educational policy and, what is more important still, the teachers' attitude and method in the classroom can then be based upon something more concrete than vaguely supported belief.

Differences between the Means of Groups

(*a*) *Verbal Ability*

Much of the evidence comes from the results of surveys of different kinds, many of them with group tests of ability. Some of the earlier ones, such as the Scottish Mental Survey of 1932, indicated that there was little statistically significant difference between the mean scores of urban and rural children on the group verbal test used. Children were divided into three main groups corresponding to the geographical regions of Scotland. The investigators found that it was difficult to generalise about difference between the scores of rural and urban children. (Table 1.)

Table I

1932 SCOTTISH MENTAL SURVEY

MEAN DIFFERENCE OF I.Q. ACCORDING TO GEOGRAPHICAL REGION

Area	I.Q.
1. The Four Cities	100.86
2. Industrial Belt	99.86
3. Rural Area	100.19

It was difficult, too, to separate areas of town and countryside because of their inter-penetration, and rarely was there a true indentity of conditions present. Racial, social and economic factors combine in a variety of ways and were considered by the Survey to have some effect on the scores, but it was difficult to match different geographical areas which had similar environmental conditions. This study concluded by noting that as far as Scotland was concerned there was no significant inferiority in the scores of rural as compared to urban children; indeed, in certain of the more remote areas of the Highlands and Islands, there might well be isolated groups of people with higher than average ability.

Working in Northumberland, Thomson found similar isolated groups of gifted people in some of the more remote Cheviot valleys. Lewis, who studied the incidence of mental deficiency, also adds his warning that only an impetuous person would conclude, from the contemporary data that rural inhabitants as a group generally are inferior in mental endowments to the inhabitants of urban areas. However, Terman and Merrill, working in America, disagreed, and stated that rural children are definitely inferior in general ability as a group to urban children and claim that this conclusion is reached by other investigators. It was supported by Burt. Testing in rural and urban schools in England he found twice as many sub-normal children in the former as in the latter.

Post-war studies have tended to support the conclusions of Terman, Merrill and Burt rather than those of the Scottish survey. In 1947 a further survey was undertaken in Scotland and a ' follow-up ' of this was made in 1954. This time a small but statistically significant difference was found in the mean scores in verbal (' intelligence ') test scores of rural and urban children favouring the latter, a difference, however, less than the average difference between boys and girls throughout Scotland.

The 1954 ' follow-up ' survey of Scotland studied the question in detail and examined the extremes of high and low scores. The investigators found that whereas 46.5 per cent. of high scorers come from the cities only 29.7 per cent. came from the rural areas. Conversely, 55.7 per cent. of the low scorers came from rural areas as compared with 21.7 per cent. from the cities.

A similar conclusion was also reached by Cross and Revell in Cambridgeshire in 1955. They compared the performances of rural and urban children in a Local Education Authority's secondary school selection examination and found that whereas the percentage of rural children in the lower scores exceeded that of urban children this majority became progressively less until it was replaced by an urban majority in verbal scores (I.Q.s) of over 120.

Table II

CAMBRIDGESHIRE SURVEY, 11+ SELECTION TEST, 1955

PERCENTAGE DISTRIBUTION OF CANDIDATES GAINING HIGH VERBAL SCORES

Area	Verbal Test Scores				
	109 and under	110+	120+	130+	(N)
1. Rural	50.4	30.2	13.3	6.1	(655)
2. Urban	41.2	27.2	19.2	12.3	(739)
Difference (Rural compared with Urban)	+9.2	+3.0	—5.9	—6.2	

(*b*) *Attainments*

In 1952 the Bristol Institute of Education investigated the problems concerning the relative successes and failures of rural and urban candidates in the 11-plus selection examination of Wiltshire and found differences in Arithmetic, Verbal and English (Moray House Intelligence) tests. A comparison of the means showed that on all tests rural candidates achieved lower scores than their town contemporaries.

Table III

BRISTOL INSTITUTE OF EDUCATION: SURVEY OF WILTSHIRE URBAN AND RURAL PERFORMANCE IN 11+ SELECTION EXAMINATIONS

Area	Mean Standard Scores			(N)
	I.Q.	English	Arithmetic	
Urban	100.60	100.23	100.68	1,126
Rural	97.69	98.58	98.55	1,304
Difference (Rural compared with Urban)	2.91	1.65	2.13	

(S.D. are all approximately 15, and a difference of 1.2 points is significant at 5 per cent.).
Source : Bristol Institute of Education publication No. 3, page 17.

This conclusion was also reached by the Cambridgeshire Survey in 1957, which found that mean standardised scores of rural children in English, Arithmetic and Verbal tests were significantly lower than those of the urban groups.

A similar result was found in a more intensive survey of sixty schools in the county of Kent, carried out in 1954-1958.. It showed that the scores of urban children in both reading and non-verbal tests were higher than those of rural children.

Perhaps the most convincing evidence, since it is based upon careful sampling of all children in all types of schools and areas in England and Wales comes from the National Foundation for Educational Research's own National Survey. The all-round superiority of urban children in the two basic subjects, and indeed in results on a non-verbal test of ability, is confirmed. How this shows itself in the most able groups is demonstrated by the following table which gives the proportions of candidates from urban and rural groups who scored 115 and above (population mean 100, and S.D. 15) on each of the three measures used.

Table IV

NATIONAL FOUNDATION FOR EDUCATIONAL RESEARCH: NATIONAL SURVEY. PERCENTAGES, URBAN AND RURAL, OF CANDIDATES WHO SCORED 115 AND OVER

Test	Urban	Rural
	%	%
1. Arithmetic (problem) ..	17.7	10.0
2. Reading	15.8	9.7
3. Non-Verbal	17.9	13.4
Average ..	17.1	11.0

It appears that the difference in attainments between the rural and urban children is most marked in reading, a fact confirmed by the Ministry of Education surveys of reading reported in 1950 and 1957.

Thus the consensus of recent evidence derived from a variety of surveys undertaken by different workers and using different tests in various parts of the country is that the measured ability and attainments of rural children are lower than those of their urban contemporaries, and that this discrepancy is somewhat more marked in verbal tests and in tests of reading than in non-verbal tests and tests of arithmetic.

Incidence of Gifted, Average and Backward Children

It is important for teachers to know what proportions of gifted, ' average ' and educationally backward children there are likely to be in their classes. Similarly, administrators will want to know the proportions of these groups which are to be expected in their areas. Both, then, can provide suitable education accordingly.

In the preceding paragraphs, and especially in Tables II and IV, some indications are given of the differential incidence of high scorers in the two broadly contrasted rural and urban groups. Other surveys provide similar approximate indications. Burt, for example, found that in rural areas there were nearly twice as many educationally subnormal children as in towns. The 1954 Scottish Survey also discovered differences; for every 5.7 low scorers on verbal tests in areas other than towns and cities, there were 2.7 in the cities whilst for high scorers the ratio was reversed: 3 : 4.7. In Cambridgeshire, over a period of ten years, 24 per cent. of the urban candidates in the 11-plus selection examination obtained Grammar School places but only 20 per cent. of the rural candidates gained similar awards.

It seems from these results, therefore, that teachers and educational administrators may expect important differences in the numbers of good, ' average ' and below ' average ' children. Indeed, we may hazard the statement that the differences in the proportion of high and low scorers may be almost as great as 2 : 1 in favour of the towns.

Possible Causes of the Differences

(*a*) *The Test Problems*

Most of those who have investigated the problem of urban and rural differences have warned against the simple ascription of the apparent inferiority of rural children to something inherent in the rural environment or the more ' stimulating ' culture of the town.

In a search for causes we must first call into question the nature of the instruments of measurement used. It has, for example, been suggested that the tests themselves may be biased in favour of urban children who respond better or more quickly to them.

One Local Education Authority was concerned about this problem and asked the National Foundation to study it. The basic hypothesis of the enquiry was that if urban children were indeed more sophisticated in answering objective tests then one would expect the gain in score between two separate administrations of similar tests to be greater for rural than for urban children. This would result from the proportionately greater increase in sophistication reaped by the ' unsaturated ' rural children over the ' saturated ' urban children.

Samples of urban and rural children were given the same verbal ability test. This was followed at a later date by a similar test. It is known that coaching improves scores initially but that further coaching or experience with this kind of test does not result in an improvement beyond a certain limit. If the town children had had experience of this type of testing they would be nearer this limit than the country children who had had little experience in answering such tests. Thus, whatever the *total* scores, achieved by either group, it would be reasonable to expect that the *improvement* between the first and the second testing would be greater in the case of the rural than of the urban children. The results of this experiment, in fact, showed a slightly opposite trend.

Table V

NATIONAL FOUNDATION FOR EDUCATIONAL RESEARCH, 1958
URBAN AND RURAL DIFFERENCES IN MEAN RAW SCORES BETWEEN TWO SIMILAR TESTS, VERBAL 8A AND 8B

Area	Mean Raw Score		Mean Gain Between 8A and 8B
	8A	8B	
Urban ..	36.83	40.70	+3.87
Rural ..	30.97	34.22	+3.25

The differences are not large in terms of standardised score and do not reach significance. The differences in favour of urban children in mean performances between the first and second testing, however, are statistically reliable. Thus, the study legitimately concludes that there is no evidence to show that the country children are at a disadvantage when compared with the town children in answering this type of test.

The investigators conducting the Cambridgeshire Survey also studied this problem of bias from a different aspect. Each item used in the English and Arithmetic tests was examined separately. They concluded that there was no evidence to support the idea that the form of the examination paper was responsible for any differences.

We are obliged to conclude that neither the content nor the type of question used in the surveys previously mentioned favours one or other group. The measured differences, therefore, indicate a reality rather than an artefact of the measurement situation itself.

(*b*) *Migration*

If this is accepted then other explanations must be sought. The one most frequently advanced is that the abler families have moved and continue to move from the countryside to the towns.

Throughout recent history there has been a drift from rural to urban areas. In 1801 about 60 per cent. of the people of England and Wales lived in rural districts or in towns with less than 2,000 inhabitants; by 1931 this percentage had fallen to 20. The drift to the towns has continued even during the last generation, particularly from the more remote parts of the kingdom. This could explain why although Thomson in 1922 and the Scottish Survey of 1932 found groups of more gifted people in the isolated parts of the Cheviots and Highlands of Scotland, such pockets no longer appear to exist according to

later work. These remnants of a vigorous peasantry may have largely migrated by now to the towns.

The 1947 Scottish Survey paid special attention to the problem of migration. It found that between 1936 and 1947, on the average, more children of under 11 years of age moved to ' Other Areas ' than vice versa. This apparently contradictory finding is explained by the unusual nature of the decade concerned, which covered the years of war when junior school age groups, in particular, were evacuated from the towns to the country. The research workers found, incidentally, that in the age groups over 11 years, the balance of the movement was the more usual one, from ' Other Areas ' to the towns and cities.

It seems probable that in general the families who leave the countryside are the more vigorous and adventurous ones. This seems to be confirmed by the finding of the 1947 Scottish Survey who compared the test scores of inward and outward migrants. The average score of city-born children migrating to ' Other Areas ' was 36.1 points; that of those who went to the towns from the countryside was 43.2 points. This, as the Report of the Survey points out, is a considerable difference. However, if there were a continual drain of talent from the countryside to the towns we should expect the gap between the abilities and educational attainments of town and country children to become steadily larger. This does not seem to be supported by the facts.

The apparent paradox is partly explained perhaps by the fact that mobility is not perfect; but there is an even more important factor. Although parents of high ability tend to have able children this does not occur invariably; some children are less gifted than their parents. Conversely, parents of poor ability do have children more able than themselves. Whatever the influence of the migration of the more enterprising to the towns, the countryside continues to produce talented children, some of whom may stay, although others subsequently migrate to the towns.

Migration thus affords at least part of a valid answer to the problem of why some early surveys found not only virtually little difference between rural and urban scores but also why some pockets of gifted people remained in remote districts. It explains why recent studies have found statistically significant differences. The above modifications of the crude hypothesis of migration can explain why the educational gap is not greater between urban and rural children. But it is unlikely to be the sole true answer.

(c) *The Problem of Country Schools*

There is a popular belief that small classes are better than large ones because they allow the teacher to give more individual attention to each child. Despite this, many parents of rural professional groups prefer to send their children to town schools often at considerable expense.

The Cambridgeshire Survey studied this paradox by constructing a table comparing the number of grammar school places obtained by rural pupils according to the size of school which they attended. The results suggest that the smaller schools, mainly rural, obtained fewer places than might have been expected, whilst the larger schools, which were situated mainly in the towns, obtained more places.

Confirmatory evidence is derived from two surveys undertaken by the National Foundation. At first, data compiled by the Population Investigation Committee appeared to support the view that smaller classes in the rural schools were favourable because they allowed more individual attention, but further analysis revealed that the smaller classes occurred mainly in private schools which were largely patronised by parents of professional occupations. This factor, rather than the size of classes, appears to be the important one.

The Kent Reading Survey found that not only were the scores of rural children poorer than those of their urban contemporaries on non-verbal and reading tests but that the high scores were typical of large schools which had good buildings and junior but no infant departments. This type of school was found to be typical of the towns rather than of the countryside, and particularly of the new housing centres of good socio-economic character. Evidence also was found which seems to suggest that larger classes are slightly more favourable to formal attainment in reading than the smaller ones, but this is a tentative conclusion on which much more evidence is needed, and it should not be interpreted to mean that large classes lead to better attainments invariably.

(*d*) *Socio-Economic Factors*

The 1947 Scottish Survey drew attention to the fact that when children were grouped according to the occupational category of their parents, irrespective of whether they came from rural or urban environments, differences related to socio-economic groups appeared. Of the children from parents of professional occupations, 9 per cent. fell in the high scoring group as compared with 4 per cent. of those from agricultural worker's families. Both this and the 1954 ' follow-up ' suggested that the superiority of town children was likely to be due less to any marked differences in the cultural opportunities of the urban or rural environments as such than to immediate family living conditions.

It will be recalled, too, that differences are most marked in verbal abilities. Describing a locality in the Pennines in which groups of miners, mill-workers and farmers were juxtaposed, Semens noticed differences in vocabulary whereby a child of an urban mill-worker would find difficulty in underlining the misfit in the following series of farming terms:

' stirk, gilt, reckling, hoggett, colt.'

These words, of course, come from a highly technical vocabulary and a similar series could be produced from almost any craft or trade, urban or rural. What is important, however, is to note the fact that differing family environments are likely to have not only differing vocabularies but vocabularies of a differing degree of richness.

This is in itself the superficial sign of more fundamental basic differences. Vocabulary represents a store of concepts; it is related to ways of life and to the richness or poverty in verbal-intellectual stimulus which the immediate environment provides for children in their earlier years. Since much of what we understand as learning ability as shown in primary and secondary school depends upon verbal-intellectual development, we should expect no small relationship between the educational and occupational level of the parents and the measured abilities of their children.

An Australian Survey of Socio-Economic Influences

Evidence exists that these conditions do occur in Australia. Urban and rural conditions were studied by Oeser, Emery and Hammond in 1949. The authors indicate that the educational environment in both rural and urban schools was closely similar since the pupils are similar ethnically, the compulsory school age fixed, the administration centralised and hierarchical and the text-books common to all State schools. Teacher training is centralised and uniform in the various colleges, and in general standards are supervised by inspectors attached to the State Education Departments. In spite of this, however, the authors found that rural children were poorer both in ability and attainments.

The Survey suggests that the differences are partly due to differences in ideology. Teachers are trained generally in an urban environment and a candidate from the country must abandon his rural background to a large extent thereafter adopting the outlook and social position of the urban professional groups.

Nor were teachers the only ones to be affected by differences of ideology because parental attitudes to school appeared to be dissimilar. In the rural areas it was found that 87 per cent. of parents disapproved of homework whilst in the smaller towns the figure was 67 per cent. In the city only 24 per cent. objected although as the authors pointed out this figure was probably biased because the parents knew that the interviewers were associated with their children's school and thus may have given what they considered to be ' acceptable ' answers.

Homework, too, was found to be a major source of tension between school and home. Parents disliked being measured by the standards of the teacher. This dislike would be less where, as in the towns, more of the parents were of similar social backgrounds and educational level to their children's teacher. Parents of an agricultural background might be tempted to disparage ' book-learning ' openly, although they may secretly respect or envy it.

Whereas urban middle-class parents tended to exert pressure on their children to do well at school because they regarded education as a means to achieve status and upward social mobility, farm parents tended to perceive higher education as a ' frill '. They believed this ' frill ' to be a good thing for their daughters as a social rather than as a vocational asset but considered it to be inessential for their sons.

Attitudes towards the curriculum differed. One-half of the town parents preferred the ' Mathematics-English-Social Studies ' subjects, but only a quarter of the rural parents agreed and instead a half of them preferred the ' handwork ' subjects. Each group, in fact, probably favoured a particular side of the curriculum for its apparent vocational value in their environments. Their children were aware of their parent's preferences and this awareness may well have influenced their attitudes towards, and hence performance in, the different school subjects.

Socio-Economic Influences in Britain

Australian and British conditions are similar. The 1947 Scottish Survey noted that high scores correlated highly with socio-economic factors such as a low average number of people occupying each room and with small families; conversely, low scores were found to be frequent among large families and with a high occupancy rate. A high score and its

correlates proved to be typical of professional groups whilst unskilled and farm-labour groups were associated with a low score and its correlates.

Confirmatory evidence is given by Floud, who investigated the patterns of grammar school success in the County Borough of Middlesbrough and the South-West Division of Hertfordshire. The former is an area of heavy industry in whose economic history boom has been followed by slump, whilst the latter area has enjoyed longer periods of prosperity. The inquiry found a close relationship between ability, as measured by verbal tests, and opportunity, as measured by entrance to grammar schools, at all social levels. When those children of clerical workers who had been given grammar school places, were combined with the similarly successful children of manual workers there was found to be little difference between the two areas, but large differences were noticed when the ratios of the two socio-economic groups were compared. Thus, in Middlesbrough the ratio of grammar to non-grammar school entrants in the clerical groups was 1 : 3 and in the manual groups 1 : 8, whilst the respective ratios in S.W. Hertfordshire were 1 : 2 and 1 : 7.

The inquiry also discovered the interesting fact that it was not so much the actual socio-economic status as measured by income which was the critical factor. The most successful children certainly came from families which were smaller and better housed, but also success was found to be more frequent where there were better educated parents who were favourably disposed towards and interested in the education of their children.

The Influence of the Home Environment

At first sight one finding of the Cambridgeshire Survey appears to be contradictory. The investigators found that once rural children entered the grammar schools their performance was more consistent from year to year and easier to predict than that of urban entrants. The Report speculated as to whether urban candidates had their attainments pushed precociously in the primary school beyond their true capacity for grammar school work, thus leading to an unstable subsequent performance. Coaching for tests within schools can be forbidden or controlled by the authorities, whilst out-of-school coaching is probably a reflection of parental interest and anxiety which is perhaps stronger in the professional and urban artisan groups than among agricultural workers who form the majority of the rural population. The child of the manual worker in town or country may belong to a family whose attitude towards post-primary education is antagonistic or at best passive. This may be one reason for some of the unstable and disappointing grammar school careers.

Regularity of attendance at school and the length of a child's school life are two reasonably objective indices of parental interest. The 1947 Scottish Survey accepted 90 per cent. as a satisfactory average attendance at school. The investigators found that only 50 per cent. of rural children reached this figure as compared with 80 per cent. of children of small employers who are probably living in urban districts.

That children from professional families are encouraged to remain at school longer than those from unskilled workers' homes is supported by the figures in Table VI cited from the Central Advisory Committee's Report on ' Early Leaving '.

Table VI

CENTRAL ADVISORY COMMITTEE, REPORT ON EARLY LEAVING
LENGTH OF SCHOOL LIFE, GRAMMAR SCHOOL BOYS AND GIRLS

Last Form at School	Professional and Managerial Groups		Unskilled Groups	
	Boys	Girls	Boys	Girls
	%	%	%	%
1. 6th	47	41	7	6
2. 5th	46	53	55	51
3. Below (at 15+)	7	6	38	43

(*Source*: Table P.)

The Report considers that one of the most important influences on the length of a child's school life is the home background. It states that the results of overcrowding are particularly serious. This handicap apparently becomes aggravated in the later years of school life and tends to falsify predictions of success made in the earlier years of the school career. Shortage of money by itself was not found to be the most common reason for early leaving; the general conflict of different social ideologies between the child's school and home environments often results in tensions which influence both the child himself as well as the parent to decide to end the secondary school life prematurely.

(*e*) *The Population Investigation Committee Data*

One of the most extensive post-war studies which provides information about rural and urban differences is that conducted by the Population Investigation Committee. Originally this investigation began as a medical and social inquiry into the development of children born during one week of March, 1946 throughout Great Britain. From the time these children entered school their educational development has been studied by the N.F.E.R. which has administered Reading and Non-Verbal tests to a sample of over 5,000 children.

When the results are analysed, rural children are found to be lower scorers than the town children if the groups are separated according to where they lived. When, however, the analysis is carried further and pupils are grouped according to the occupational status of their family, the crude rural-urban differences tend to disappear. A comparison of the urban and rural professional groups reveals that the difference between their mean scores is negligible; a similar comparison of rural and urban manual groups likewise shows little significant difference. However, when the mean score of the combined urban and rural professional groups is compared with that of all those employed in manual occupations there appears a significant difference with the former achieving the higher mean scores.

Thus, in common with the other large-scale surveys already considered the P.I.C. data reveals a strong positive correlation between test scores and socio-economic environment, not only in parts of the country but throughout the country as a whole.

Conclusion

From all that has been stated, it is clear that as a group, children from rural schools are likely to have lower mean scores on verbal tests and on tests of the basic school subjects than their urban contemporaries. Practically, this means that there are likely to be proportionately fewer academically able and more academically weak children in the countryside than in the towns and suburbs. However, since the main influence at work is not the nature of the rural or urban environment itself but rather the structure of the socio-economic group from which any school draws its pupils, there will be exceptions to this general tendency: moreover, any reversal of the trend, for example, for the abler and more enterprising families to migrate to the towns, will bring about a quite different state of affairs. In terms of educational provision it is clearly necessary for an educational authority to have a rough estimate of the different mental make-up of urban and rural groups and at the same time to have some idea of past and present population trends. It seems likely, too, that in the past some rural schools have been too much under the influence of urban ideologies, educational method and content on the one hand and less well provided materially than city schools. If this has coincided with a larger proportion of dull pupils for whom no special provision is made, there has been something of a handicap for pupils and for teachers.

The most important single factor, however, associated with differences in ability as revealed by these studies is that of the level of encouragement a child receives at home—a factor related to the socio-economic level and education of his parents. Mothers and fathers who are really interested in their child's education and who maintain this interest throughout his school career seem to contribute greatly to his success. Even in relatively adverse material conditions this seems to apply; conversely apathetic or antagonistic parents constitute a grave handicap even for the ablest child.

This, however, raises two problems on which practical experiment and research are clearly necessary. We know little as yet about the intimate ways in which 'parental encouragement' affects the growth of children intellectually. Of more immediate concern, however, because it lies in the teacher's own province, is the practical question of what the school can do in some measure to compensate for any deficiencies in the child's home environment once they are manifest. Here there is room for the practicing teacher to carry out experiments which can only be of value.

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THE RELATIVE EFFECTIVENESS OF DIFFERENT METHODS OF TEACHING READING

B. The Place and Value of Whole-word Methods

I. Introduction

by JOYCE M. MORRIS

DIFFERENCES in terminology impede any attempt to evaluate scientific evidence on the relative efficiency of different methods of teaching reading. There is, however, some agreement among authorities that most reading methods may usefully be classified into two broad groups on the basis of the psychological processes presumed to be involved. ' Synthetic ' is the term frequently used to describe those methods which build up a recognition of wholes (words, phrases, and sentences) from parts (letter-names and sounds), and ' analytic ' refers to those which begin with a recognition of wholes as units of meaning from which their constituent elements are broken down. Thus, the alphabetic, syllabic and all phonic methods constitute a synthetic approach to reading whilst whole-word methods, which include the word, phrase, sentence and story methods, may be defined as analytic. Alternatively, the latter are sometimes described as ' global ', ' syncretist ' or ' ideo-visual '.

On the whole, educationists in English-speaking countries today consider that the synthetic work involved in the first group of methods is too difficult for beginners in reading and is in any case ' psychologically unsound ', being contrary to the principles of child development. Consequently, they advocate an analytic approach after children have enjoyed an informal period in which to develop confidence, an interest in books, and the necessary desire to read without which any method is useless. Later on, when a sight vocabulary has been acquired, instruction in breaking down words into smaller units is recommended in order to give pupils a technique for deciphering new words.

Research into the place and value of phonics in the reading programme (see first article in this series) would appear to support the view that whole-word methods should precede any systematic phonic teaching, for, in most studies, a successful use of synthetic methods has been shown to depend upon the level of maturity of the pupils. Thus, intelligent children, or those from home backgrounds rich in linguistic resources, will generally have reached an adequate stage of phonic readiness in the reception class, whereas for those who are dull or handicapped in any other way, systematic phonic instruction may desirably and safely be postponed until later in the school course.

It should be pointed out in this context that the successful use of a synthetic approach to reading by some non-English-speaking countries, particularly those of Scandinavia, does not contradict this idea that analysis should precede synthesis in the teaching of reading, since children in these countries start school at least one, often two, or even three years later than their English contemporaries.

The value of whole-word methods cannot, however, justifiably be inferred solely from a study of the use of phonic methods: the case for analytic methods of teaching reading must be examined in its own right. In doing this one may look at the historical development of the notions concerned and their embodiment in current educational practice.

II. Historical Background

Comenius is usually credited with the introduction of the word method. His *Orbis Pictus—The World of Sensible Things Pictured*, published in 1657, was, according to Monroe, the first illustrated textbook for children. In this he argued that when words are presented along with pictures representing their meaning " reading cannot but be learned—and indeed too, without using any ordinary tedious spelling—that most troublesome torture of wits."

It was not until the beginning of the 19th century, however, that Comenius' revolt against the established synthetic methods of teaching reading received strong support from educators. In France, Jacotot, advocating the use of visual methods, too, suggested that words rather than letters should form the child's introduction to reading. He even went so far as to state that, if a child learns by heart a sentence or a page of something, he will divide it for himself into words, syllables and letters, and be able to recognise them later in a different context.

About the same time, Worcester, in America (quoted by Smith), was writing in his *Primer of English Usage:* " It is not, perhaps, very important that a child knows the letters before he begins to read. It may learn first to read words by seeing them, hearing them pronounced, and having their meanings illustrated, and afterwards it may learn to analyze them or name the letters of which they are composed." His compatriot, Horace Mann, shared this view of children's development and strongly criticised the current letter-by-letter system of teaching reading, preparing the way for the first (mid-century) American readers specifically based on whole-word methods.

Froebel and Dewey indirectly, and Vogel with his ' method of normal words ', made further contributions to the ' whole-before-part ' school of thought. It was Decroly in Belgium, however, who, at the close of the century, carried their ideas to a logical conclusion by insisting that as one reads primarily for meaning the sentence is the appropriate unit for beginning reading.

Decroly exerted a strong influence on the development of whole-word methods of teaching reading. Indeed, it is often asserted that, except for the fact that children now are encouraged to handle books right from the start, the teaching in infant classrooms is basically Decrolian in character. The climate of educated opinion at the end of the first world war, or even before it, favoured a less mechanical approach to reading than had hitherto been in vogue. The difficulties of a phonic approach for very young children had become apparent. Many pupils, for example, stuck at the point of being able to sound out the letters but were unable to synthesize the individual sounds into words. The letter-by-letter peering at words encouraged by this method was neither conducive to speed nor fluency. Moreover, when giving phonic instruction, teachers found it difficult to make themselves heard at the back of a class without adding a distinct vowel sound to some letters, so that ' p ' became ' per ', ' f '—' fer ', and so on.

The weaknesses of synthetic methods seeming thus to be exposed, it is not surprising that the ideas of educators like Decroly exercised an increasing influence on teaching practice. Unfortunately, as is often the case, the pendulum swung too far in the other direction—so much so that, according to Gray, American teachers during the late twenties and early thirties were advised to consider meaning as almost the only factor in word perception and to expect their pupils to identify new words by guessing from the context.

Experienced teachers are rarely persuaded to change their methods by the voices of articulate radicals alone and many continued to give systematic instruction in word-analysis skills. In the middle thirties, however, some of the ideas of the Gestalt psychologists on visual perception began to penetrate to the schools, and appeared even to some of the more sceptical teachers to give psychological colour to practice in the ' progressive ' schools.

The fundamental hypotheses of the Gestaltists will be discussed later: here we may remark that recently experimental psychologists have tended to discard much of this early work. Vernon, for example, who in 1937 devoted considerable space in her book *Visual Perception* to Gestalt psychology, stated seventeen years later:

> " The apparently clear outlines originally drawn by the Gestalt psychologists have become blurred and dimmed. And it has seemed perhaps that their experimental results and their theories did not after all indicate a fundamental basis for the understanding of the nature of perception, but rather a one-sided exaggeration of certain features by no means the most important in perceiving as we ordinarily experience it."

In contrast, educationists generally have continued to stress the support given to whole-word methods by the Gestaltists. The following statement from *Backwardness in Reading*, by Duncan, is typical of many:

> " We tend to see a whole word-pattern before we see the parts of it. A young child may recognize the word ' elephant ' long before he knows the component letters. It is a distinctive ' word-pattern '. Even the most backward older pupils, who do not know letter-sounds, although they may have been ' drilled ' in them for years, recognize the words ' ice-cream ', ' orange ', and ' lemonade '. This tendency to see in ' wholes ' is emphasized in the *gestalt* hypothesis."

One wonders how such conflicting opinions can exist side by side until it is realised that psychologists interested in an experimental approach to visual perception are concerned mainly with the fundamental Gestalt hypotheses themselves, whereas educationists usually concentrate attention on practical consequences which may derive from them. If teachers are to feel confident in the use of whole-word methods for beginning reading, a re-examination of the part played by Gestalt psychology in their development is very necessary.

Strengthened by the rise of the ' experience ' approach to learning in the thirties, Gestalt theories undoubtedly influenced development towards greater attention to word meanings and contextual clues. The look-and-say method of individual word recognition was ' old ' in 1933, according to a Board of Education report. By then the sentence method for beginning reading, which implies not merely a single, relatively uncomplex visual gestalt but a much more complex, contextual and meaningful one in which visual clues do not dominate, had taken its place in many English schools. Educational practice had, in fact, far outrun such evidence as was provided by the actual experimental data of the Gestalt psychologists.

As might have been expected, there was a certain amount of criticism of this development in teaching practice, but not until the war years, when the extent of illiteracy among the Armed Forces was revealed, did it become serious. Public opinion, aroused by the

Press, virtually demanded that educationists should re-assess the validity of the methods by which reading was taught in primary schools. A series of investigations by local education authorities and the Ministry of Education in England certainly produced evidence of a deterioration in children's reading standards. This was ascribed largely to the disruptive effects of the war but other contributory causes were suggested. There was no recommendation of a return to early systematic phonic instruction and no general attack on the use of analytic (either word-whole or sentence) methods for beginning reading apart from a criticism of their exclusive use. Inquiries in America and other countries resulted in similar conclusions.

If indeed teachers follow the advice of authorities on the teaching of reading, the word-whole method, or the later sentence approach of the thirties, should predominate in the reception classes of our schools. How far this is a fact must be judged from recent inquiries.

III. Whole-word Methods Today

A clear picture of teaching practice in any large area is difficult to obtain. Even in one school, long classroom observation is necessary before a refined and reliable assessment of the methods used in the early stages of teaching reading can be made. It is misleading, too, to speak of different reading methods as though each were self-contained, and as if teachers confined themselves to one particular method, and are consistent in their approach for all children. Nevertheless, broad trends towards an analytic or synthetic approach may be distinguished.

According to Duncan in an appendix to *Language*, a 1954 publication of the Ministry of Education, " in general, in the United States of America during the past twenty-five years the use of phonic work in teaching reading has disappeared. No widely circulated readers published in that country in recent years has any phonic basis nor contains any phonic work." Russell's inquiry, described in a previous article, would suggest that this is a rather exaggerated view of the situation. It is, however, probably true to say that analytic methods predominate in American schools today, at any rate in the early stages of learning to read.

In this country as a whole no recent survey of current trends has been carried out, and the opinions of educationists conflict to some extent. Duncan, for example, states that synthetic methods have been out of favour in English schools for some years, and Daniels and Diack appear to support his statement. Gagg, on the other hand, from a knowledge of over 400 schools, challenges their observations and points out that, whilst whole words usually form a child's introduction to reading, " infant teachers do in fact use ' phonics ' and that in almost all the popular published reading schemes phonic practice is found."

Conclusions about teaching practice in England, drawn either from individual observers or from a study of one county, are obviously of doubtful general validity. There is, however, some evidence from the Foundation's recent Kent inquiries (Morris) which backs up the description of present practice given by Gagg. In these studies, as will be seen in Tables 1 and 2, a distinction has been made between the ' word ' and ' sentence ' methods, although both represent stages in the evolution of analytic methods.

Table 1

DISTRIBUTION OF READING METHODS USED IN THE INFANT DEPARTMENTS OF SIXTY KENT SCHOOLS

Methods*	Urban Schools	Rural Schools	Total
A+B+C+D	0	4	4
B+C+D	32	15	47
B+C	2	7	9
TOTAL	34	26	60

*A—Alphabetic. B—Phonic. C—Word. D—Sentence.

All schools in this random sample used both analytic and synthetic methods of teaching reading, although a tendency for rural schools to favour the latter may be observed in the tables. In four village schools, experienced teachers, having obtained satisfactory results with a previous generation by the alphabetic method, continued to use it in conjunction with other methods. Teachers in nine schools, also of rural type in spite of the fact that two were in districts administered by an urban authority, considered that the sentence method was not particularly suitable for 'the slower type of child attending a country school'. They firmly believed that, if pupils rely too much on contextual clues, they do not gain skill in recognising individual words. Children in these schools were, therefore, taught mainly by the phonic and word methods, and sentences were only introduced at a third stage when some facility in word building and recognition had been acquired. Similarly, in the more important choice of methods for beginning reading (Table 2) a sizeable proportion of rural schools appeared to be disregarding modern educational theory by using a synthetic approach.

Table 2

DISTRIBUTION OF METHODS USED IN COMMENCING TO TEACH READING IN SIXTY KENT SCHOOLS

Methods	Urban Schools	Rural Schools	Total
Sentence	12	8	20
Word	10	8	18
Phonic	5	8	13
Sentence+word	3	2	5
Sentence+word+phonic	4	0	4
TOTAL ..	34	26	60

This survey in Kent schools clearly demonstrates the freedom given to English teachers to decide the manner and content of their teaching. At the same time it gives evidence of the continued popularity of word and sentence methods for beginning reading.

A similar bias in favour of analytic methods is also revealed in a report published in 1949 by the International Bureau of Education on the teaching of reading in forty-five countries. Apparently, wherever synthetic methods are still widely used, it is often the

form of the language which dictates this practice. In Burma, for example, " the particular formation of the Burmese letters is one of the chief causes of difficulties in learning to read, and would appear to force teachers in many schools to use the spelling method." Regularity of spelling is not always conversely a guarantee that synthetic methods will be adopted for, although Turkish is one of the world's most regularly spelt languages, schools in Turkey have abandoned this practice in favour of analytic methods. Moreover, a non-synthetic approach is making headway in France and Germany, despite the fact that French and, particularly German, are more regularly spelt than English.

That analytic methods are widespread does not mean that they meet with unqualified approval in all quarters. Diack, for instance, states that there is little scientific justification for what he considers to be the most frequently quoted observations in favour of ' visual pattern—whole-word theory ', namely, that " fluent readers skim along and do not pause to analyse words into letters," and " children recognise some words by their general shape." Having examined and dismissed some of the experimental work on which this theory rests, he concludes that " ' look and say ' derives its strength from at least two other sources: (1) apparently quick results—but how deceptive! (2) the ease with which reading material can be produced when any word will do."

Replying to this attack on whole-word methods Whitehead points out that, in this country at any rate, no one has contended that children can complete the process of learning to read by these methods alone. Even ardent supporters of analytic methods, like Boyce, give detailed advice about training in word analysis, although such instruction is generally regarded as more appropriate for first-year juniors than for infants.

In Whitehead's opinion the arguments in favour of visual pattern—whole-word theory referred to by Diack have more cogency than Diack recognises " since (1) it is helpful to future progress to establish from the beginning habits of eye-movement along the line of print which are similar to those used by the mature reader, and (2) there is clear evidence that children develop the visual power of discriminating between whole words earlier than that of discriminating between individual letters." Furthermore, Whitehead considers that Diack has omitted to mention two considerations which are usually regarded as far more decisive. First, through analytic methods, particularly the sentence method, " the child from the beginning practices reading as a process of obtaining meaning from printed symbols—and that after all is the essence of reading." Secondly, " because of this (and because of the *comparatively* wide range of words which can be used under this method) it becomes much easier to maintain the purposeful interest and desire to learn which is all-important for young children."

Whitehead's comments and those of other educationists show that the dispute about analytic methods centres on one main question. Should whole-word methods be used to *introduce* children to reading? In attempting to answer this question from the results of research, it is necessary not to lose sight of the fact that the teaching of reading cannot be treated merely as a technical problem in linguistics, but must be considered in its broader, human context of the classroom environment appropriate to young children when they start learning to read.

IV Psychological Rationale of Whole-word Methods

(a) Early experiments

Our knowledge of the psychological processes involved in reading is based mainly upon laboratory experiments conducted during the latter half of the nineteenth century. Until this time it was generally believed that words are read by compounding the letters. In 1885, however, J. M. Cattell dealt a severe blow to the, then widely used, alphabetic method by demonstrating that words are not read by spelling them out.

Using a tachistoscopic technique he found (according to Woodworth and Schlosberg) that, with a very brief exposure under adequate illumination, his subjects could apprehend equally well three or four unconnected letters, two unrelated short words, or four connected short words. Since even the two short words, not to speak of the four-word sentence, exceeded the letter span, and since a familiar short word could be read as quickly as a single letter, Cattell reasoned that the reader's basis for word recognition must be the ' total word picture '.

Three years later Erdmann and Dodge confirmed Cattell's findings. They reported that, whereas the span for unconnected letters was only about four or five, familiar words, even as long as twelve or twenty letters, were correctly read from a single exposure of one-tenth second. From this they inferred that the ' general word shape ' must be the primary cue for word recognition with a few clear letters close to the fixation point as supplementary cues.

About the same time, studies of the behaviour of the eyes in reading invalidated an earlier assumption that they move continuously along the line. It was discovered that the eyes execute a series of short, quick movements, fixating at several different points (either words or groups of words) along each line according to the reader's familiarity with the material, its difficulty, and its interest for him.

These early researches supported the newer concept of reading for meaning put forward at that time by educators such as Decroly. They are frequently quoted in the textbooks for teachers as providing evidence of the advisability of teaching reading by whole-word methods. Yet, it must be remembered that much of this early work was carried out with adults who could already read. As Diack points out: " If evidence drawn from adult readers gives validity to the argument that children ought to be taught by ' visual pattern ' means, then surely it is also valid to say that because an adult pianist sees and plays whole chords and phrases automatically there is no need for beginners to do five-finger exercises or scales."

Advocates of whole-word methods for beginning reading might challenge their critics in a similar manner, for a good deal of the evidence in support of early systematic phonic instruction stems from work with older, backward children. It seems equally invalid to deduce that methods which are eventually effective with pupils who have already failed to learn to read as infants are appropriate for young children at the very beginning of their school career.

Likewise those who quote the original work of the Gestaltists in support of analytic methods may be criticised, since the early findings of this school of psychology were founded not on the visual perception of printed symbols, i.e. letters and words, but mainly on

optical illusions. Furthermore, as in the pioneer experiments referred to above, except for a few studies of mathematical and quasi-mathematical problems, adults were used as subjects and not children, although deductions about the latter were frequently made.

There appears to be a strong case for limiting discussion on the psychological rationale of whole-word methods to evidence from research with children. However, as already stated, Gestalt psychology played such an important role in the development of analytic methods that a brief examination of some of its basic concepts is called for first of all.

(b) The influence of Gestalt psychology

In 1912, when phonic methods were still flourishing in the schools, three German psychologists, Wertheimer, Koffka and Köhler, openly expressed their discontent with the current associationist, or ' bricks-and-mortar ' psychology, and so laid the foundation of the school of Gestalt psychology. They considered that human experience has a natural unity or ' wholeness ' and is more meaningful than had hitherto been suggested. Thus, they argued, we must not work ' from below upward ', i.e. building a whole from its parts, but rather ' from above downward ', so that starting with the meaningful whole we increase our understanding by finer and finer discriminations of the parts. Ellis, translating from the German, defines a ' gestalt ' as " a whole the behaviour of which is not determined by that of its individual elements but where the part-processes are themselves determined by the intrinsic nature of the whole." Accordingly, the main aim of Gestalt psychology was to determine the nature of these wholes which are ' more than the sum of their parts '.

Unfortunately, in pursuing this aim the reading process was not subjected to specific examination, and educationists attempting to apply Gestalt hypotheses in detail to classroom practice made deductions which are not necessarily valid. It is true, nevertheless, as Woodworth points out, that Gestalt psychologists believed that associationist psychology, applied to education, supported the traditional emphasis on drill whereas their own theories offered the only hope of children being educated to depend on their intelligence and not on rules. At the close of his career Wertheimer summed up this view as follows: " Repetition is useful, but continuous use of mechanical repetition also has harmful effects. It is dangerous because it easily induces habits of sheer mechanized action, blindness, tendencies to perform slavishly instead of thinking, instead of facing a problem freely."

So far enough has been said to make it clear that Gestalt *theory* rejects synthetic methods and favours a whole-word, meaningful approach to reading. This is only of academic interest, however, unless accompanied by scientific evidence and of this, in the generally accepted sense of the term, there is very little. In much of their work on *human* behaviour, the early, major Gestaltists tended to *demonstrate* phenomena rather than conduct research according to a rigorous experimental design. A few examples of the phenomena used to illustrate some of the main Gestalt principles will, therefore, suffice to show how educationists have often come to accept the work of this school of psychology as ' evidence ' for a whole-word approach to reading.

The perception of a whole before its parts, and the tendency for a whole to dominate and be more than the sum of its parts, was demonstrated in Wertheimer's classic experiments on visual movement. The aim of these studies was to account for the movement seen, for example, in looking at a motion picture, which in objective fact is a series of ' stills ' separated by intervals of darkness. Wertheimer's conclusion that this ' Phi-phenomenon ' is the result of actual motion in the brain is interesting, but the importance of his work lies in the inference drawn that experience has dynamic wholeness and meaningfulness. Translated in terms of the reading process, this inference implies that a sentence is much more than, and qualitatively different from, the sum of its separate letters, sounds or even words, and will be perceived as such.

If, however, this tendency to perceive wholes before parts operates simply it ought also to be a source of confusion in learning to read. The Gestaltists believed (using figures and geometric forms for their demonstrations) that if, for example, a whole figure appears as circular, slight irregularities are overlooked. By analogy, it would seem that, children would naturally ignore differences in words of similar shape unless specially instructed to detect them.

Another Gestalt law quoted in support of whole-word methods is that of ' proximity '. Dots were effectively used by Wertheimer to demonstrate that they are likely to be seen in groups. Thus, in reading terms, just as . . . . is seen as two groups of five and three dots respectively, so ' brown owl ' will be seen as two words and not as eight separate letters.

Gestalt psychologists also played down the role of experience in learning and underlined the importance of insight. They stressed intuitive knowledge and, mainly on the basis of illusion experiments, formed their famous doctrine of the ' innate organisation of perception ', which claimed generally that from infancy we perceive the world in the complex, articulated way that we do as adults. From this it would follow that a child's knowledge of two-dimensional form is innate and he will not experience any difficulty in perceiving the pictures and word shapes that he encounters in his first reading book.

Deductions about child development made from the results of inquiries into adult behaviour are naturally suspect, but the difficulty of discovering exactly what a child perceives has led many educationists to accept Gestalt ideas. Before passing on to what is known about *children* which might justify a whole-word approach to reading mention should be made, however, of one piece of evidence which, again by analogy, would appear to throw some light on the difficulties encountered by young children in organising their visual experiences.

Senden (quoted by Hebb) examined the attempts at visual perception of congenitally blind patients who had been successfully operated on for cataract. If his evidence can be accepted, these cases experienced the ' figure-ground ' phenomenon of the Gestaltists almost immediately after operation, but they had the utmost difficulty in differentiating between simple shapes such as a square, circle and triangle. Even the development of simple shape perception would seem to require slow and laborious practice, how difficult must it be, therefore, for a young child to discriminate between words, particularly those of similar configuration!

(c) The development of visual perception in young children

The effectiveness of any method for beginning reading, whether it be analytic or synthetic, obviously depends on the readiness of children to make use of it. Factors such as school adjustment, language development, physical and mental maturity, as well as adequate motivation, are very important, but as Dolch points out, " perceptual development is more crucial than any of the others since without perceptual ability, ' telling one word from another ', there is no reading."

Since the accurate perception of shape and pattern, which must logically precede word or letter discrimination, is not very important until a child begins learning to read, few scientific investigations of perceptual development in pre-school children have been carried out. It appears, however, that although children on the average, according to Griffiths, start to look at pictures as early as their second year, their perception may be partial and vague considerably beyond this age. For this reason many authorities insist that children should be able to name pictures without difficulty before beginning reading, and consequently include this type of activity in their reading readiness tests.

More important for reading than picture naming, however, is the ability to perceive two-dimensional shapes without evident representational meaning. How soon this ability develops is doubtful, but there is some evidence that before five years of age the average child will be able to recognise simple, outlined geometrical figures. The more complex figures, as Bender and other investigators have shown, are not fully grasped until later for, although children under five appear to have some awareness of details within a figure, they generally cannot reproduce them. A mental age of seven-plus as the border-line for reasonably accurate form perception has also been reported.

So far the widely-held opinion that young children tend to see shapes as wholes would seem to have some foundation in fact. There are, however, other experiments which show that syncretist perception in children depends on the ' goodness ' of a shape, i.e. in the Gestalt sense of the word, for whenever children have been presented with a relatively unstructured form consisting of salient details the latter have tended to dominate their perceptions. Consequently, further research on this aspect of early form perception needs to be carried out before a final verdict may be given.

In contrast, research workers agree that young children have considerable difficulty with the *orientation* of shapes. Frank, for example, found that the tendency to confuse shapes (represented by playing cards) and their mirror images decreases significantly as children get older, a finding confirmed by Davidson's experiment with silhouette shapes resembling word outlines. The fact that shapes are readily reversed has also been demonstrated by Hildreth and others.

Many psychologists have found, too, that the *sequential order* of shapes presents difficulties for the young child. Teegarden, for instance, asked children who had not yet begun learning to read to name pictures of familiar objects which had been arranged in five rows each of five columns. She reported a singular lack of consistency in the direction of movement used by the children in carrying out this task. This finding has an evident bearing upon the development of skills of word recognition, the aspect of beginning reading to which we now turn.

(d) Cues to word recognition in the early stages of reading

A high correlation between success in the early stages of reading and the ability to perceive and reproduce meaningless shapes might be expected by those who subscribe to the visual pattern—whole-word theory. Various experiments have been carried out to test this hypothesis but none so far has produced a correlation of more than .5. It may be that those, like Kendall, who found no significant relationship, concentrated too much attention on the perceptual abilities of backward readers. A more likely explanation, however, is that too little importance has been attached to the perceptual training and reading instruction previously given to children taking part in these studies. Apparently, in spite of the low correlations reported, a certain minimum perceptual ability is required for reading, but there is evidence that training in the perception of visual form assists children in the beginning and improves their subsequent progress.

Similar difficulties arise in weighing the evidence on how and when children perceive words and letters. Much of the research on this topic has concentrated on the errors children make in word recognition *after* they have been in school for some time. A less vulnerable justification for the widely-held beliefs that analytic methods for beginning reading conform to the ' principles of child development ', and that children see whole words before they distinguish their component parts would come from studies of the child's first encounter with words.

An investigation by Ilg and Ames is of this kind. They studied a group of children at each six-monthly age level up to five years and beyond, from the stage of patting an identified picture to silent reading—and reported that it is ' natural ' for children under five to recognise and spontaneously demand to print *capital letters*. Other investigators, such as Wilson and Flemming, also tend to confirm that children are letter conscious in the earliest stages of reading.

Daniels and Diack explain the observation of Ilg and Ames on the ground that in children's alphabet books capital letters appear and are more stressed than lower-case letters—an evident environmental rather than genetic factor. This contention may be true, but, while not irrelevant to the main argument, and certainly so if this pre-school environment were under educational control, this preference for the more striking letter patterns at the age of beginning reading cannot be ignored.

Those who support analytic methods for beginning reading frequently refer to a study of pre-school children made by Gates and Boeker in 1923. Gates summarises the results of this early experiment in his book, *The Improvement of Reading:*

> " It was found that beginning pupils observed primarily the length of words and depended upon the observation of the length for later recognition when they were given such a series of words as *cow*, *postman*, *dress*, *duck*, *football* and *dandelion*. To these children differences in length were the most obvious differentiating features. When, however, the words presented at the same time were substantially the same in length the pupils tended to study the words until they found some small but outstanding detail, such as the dot, over the *i* in *pig*, the ' funny cross ' in *box*, the similar beginning and ending of *window*, and the ' monkey's tail ' on the *y* in *monkey*."

From this and other research Gates concludes that, although children seize upon salient details in a word at quite an early stage, dependence upon this method of perceptual attack may lead to difficulty unless other cues to word recognition are developed. These involve synthetic methods such as the use of letters, phonic analysis and syllabification. For beginning reading, however, Gates would seem to approve of an analytic approach since he states that: " In general, the best procedure is to attempt first to recognise the word as a whole."

Some investigators like Frank (cited by Vernon) go so far in their support of whole-word methods as to state categorically that young children perceive the general structure of words and neglect details. Such a finding is in general conformity with the Gestalt hypothesis and the studies of early form perception mentioned earlier. But we must remember, too, that most normal children will have achieved accurate perception of simple forms at a mental age of five-plus. Thus, Frank's observations and those of investigators who claim that children are letter conscious when beginning reading are by no means as contradictory as they appear at first sight; it is at least possible that—whether by environmental pressures or by maturation—the earlier power of gross global perception has been augmented by finer discriminations.

A number of studies have shown that children learn fairly soon to recognise the shapes of certain *isolated* letters. Nevertheless, mainly because letters by themselves are meaningless to a child, advocates of whole-word methods recommend that the shape of single letters should not be taught until a basic sight vocabulary has been acquired. Research findings endorse this recommendation since young children experience considerable difficulty with the orientation of letters with a similar shape. Reversals such as ' b ' for ' d ', ' p ' for ' q ', and inversions like ' b ' and ' p ', ' n ' and ' u ', are common and seem to persist, though with diminished frequency, even with normal readers up to seven or eight years.

It must be remembered that the direction in which letters and words are read is, like the letter symbols themselves, an arbitrary convention. It is not surprising, therefore, that young children are unable to recognise the importance of the order of letters in words. Davidson found that forty-six per cent. of the errors in word matching made by five-year-olds were reversals. Reference to the ' reading gradient ' of Ilg and Ames shows that the transposition of letters within words and complete word reversals, such as ' saw ' for ' was ', persists up till eight or nine years, i.e. longer than letter reversals.

Tendencies to reversals and inversions either of letters or words seem to be at least partly the result of immature perceptual development. Nevertheless, it has been shown, and is indeed self-evident, that some training and practice in the direction in which words should be read—that is in their convention—is essential if normal progress is to be maintained. This is particularly necessary if an analytic approach is adopted, since whole-word methods do not naturally impose any particular habit of directional attack on individual word patterns, although they give greater help than synthetic methods by way of contextual clues. It seems important, therefore, to supplement analytic methods by practice in writing words, since by kinaesthetic experience children will acquire the ' feel ' of a word from left to right.

(e) Reading for meaning from the beginning

Up to this point attention has been focussed mainly upon certain factors in the development of visual perception which might influence the choice of methods for beginning reading. A few inconsistencies in the findings will have been observed, but these may be due to the failure of some investigators to take into full account the influence of the children's experiences prior to the experiment. More research is needed, but, even when the development of visual perception is considered by itself, there appear to be sufficient grounds for the belief that initially an analytic approach to reading is likely to be more suitable than a synthetic one.

Reading, however, is much more than the mechanical recognition of words; it is a thought-getting process involving meaning and purpose and as such a logical development of language. It follows, therefore, that in deciding the appropriate method for introducing children to reading, careful attention must be paid to the role that spoken and written language plays not only in the reading lesson itself but in any present or future learning situation.

In *The Language and Mental Development of Children* by Watts we are told that " the average child enters the public elementary school at five plus with a vocabulary of at least 2,000 words (ample for any educational adventure with an intelligent teacher)." These words are ' wholes ' with meaningful associations which may be used either singly, in a phrase, or in a sentence, to express ideas—the natural units of thought. Since whole words and not letters, sounds, or syllables are the natural units of linguistic expression it seems logical that whole-word methods should be used to introduce children to reading.

Even those who consider that not enough emphasis is placed upon synthetic methods, agree that since children's speech consists of whole words, early reading ought also to be based on whole words. The new *phonic-word-method* of Daniels and Diack, resembles analytic methods in " its insistence upon reading for meaning and in not teaching the sound values of letters in isolation from whole words."

Previously, it was generally asserted that whole-word methods develop the ability to read with speed, fluency and understanding, but fail to encourage the accurate word recognition and correct spelling which follow from a synthetic approach. There is, naturally, very little proof of the soundness of this contention since it has been shown that most teachers supplement whole-word methods by synthetic methods at some stage.

Visits to over a hundred primary schools in connection with the Foundation's recent inquiries suggested that classrooms where materials based upon a whole-word *introduction* to reading were being used were generally more attractive and stimulating than those few in which the accent was on the acquisition of phonic skill. Although this kind of observation may be considered ' unscientific ', the fact that it has been repeated over and over again by school inspectors and the like would suggest that its validation could be obtained.

Summary and Conclusions

Arguments for and against whole-word methods of teaching reading become so heated that it is easy to lose sight of the fact that the main problem in the first years is that of the correct timing of the various approaches. Children under five years of age

generally find difficulty in perceiving small details in shapes. Normal pupils in the reception classes of our schools will have developed the ability to perceive simple figures, but will not be able to remember and reproduce accurately more complicated forms such as words, although they may be aware of their details. Accurate form perception, like phonic readiness, is apparently not achieved by most children under normal educational conditions in this country, until a mental age of seven. This means that some children even in the upper junior school will still have difficulty with the orientation and sequential order of letters in words. Conversely, the abler children—and particularly those whose early years have been rich in pre-reading experiences—will achieve perceptual maturity much sooner and in some cases by the time they start school. Thus, a synthetic approach to reading with its emphasis on small, meaningless parts of words is likely to be more difficult for most young children than a more analytic, word-whole one.

There is no suggestion that children can learn to read by word, phrase, sentence and story methods alone. Even when these methods are used in the early stages, as would seem appropriate, there is need for plenty of writing experiences to emphasise the left-to-right directional attack upon words. Synthetic methods, too, are necessary at a later stage to develop greater accuracy in word recognition, and to give children a means of tackling new words independently.

Children in the reception class will be at various stages of reading readiness requiring different methods of teaching. The majority will need to start with a whole-word approach followed later by phonic instruction based upon the vocabulary already acquired and understood; a few, because of high intelligence and a favourable home background, will be beyond the introductory, analytic stage, and ready for phonic training and word building immediately.

Readiness, which involves a certain perceptual, intellectual, emotional and social maturity in children, is clearly the key to the successful use of both analytic and synthetic methods of teaching reading. In deciding the best method or methods for children at any stage of development it is important, however, never to forget that the purpose of reading is to obtain *meaning* from printed symbols. Whole-word methods for beginning reading, properly applied, achieve this object naturally, but unless used with care, synthetic methods may fail to do so. The end result is of such vast educational significance that this must be the primary justification for any method.

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A STUDY OF VOCABULARY ACHIEVEMENT IN THE ENGLISH LANGUAGE IN SECONDARY SCHOOL CHILDREN

Thesis submitted for Ph.D., Leeds, 1958.

by D. G. Burns

Aim

The principal purpose of the enquiry was to classify a list of words using children's definitions as a criterion. The definitions were supplied by senior pupils in secondary modern schools and it was hoped that the classified list could be used as a standard of reference for younger pupils in the same type of school and for young adults (over 15 years of age) who had recently left school.

Method

The enquiry fell into two parts: (*a*) the preparation of a list of words which children in secondary modern schools were likely to meet in reading; and (*b*) an examination of the definitions of these words given by pupils in their third year of study.

(*a*) It was assumed that children in their third year of study in secondary modern schools (ages 13 and 14) might be able to give definitions of some 9,000-10,000 words and a list of this size was compiled from various sources. The principal source was *The Teachers' Word Book* and all words in the frequency ranges from AA to 5 (roughly 9,200 in all) were provisionally included. A separate enquiry was made to discover the books, newspapers and other periodicals read by children of this age attending secondary modern schools in an urban area and a list was made of the words occurring in samples taken from these sources which did not occur in the selected portions of *The Teachers' Word Book*. This provided some 750 additional words. It was evident that many of the words in this provisional list would be known to pupils when they entered the secondary modern school at 11-plus and, in fact, investigation in the schools revealed that nearly all pupils were familiar with some 4,800 of them. There were also a number of words taken from *The Teachers' Word Book* (archaisms, abbreviations, foreign words and—words unlikely to be familiar to British children like *campus*, *chipmunk* and *levée*) which did not seem relevant to the enquiry. These and the words known to most children at 11-plus were deleted from the provisional list, and the remainder (some 4,700 words in all) were classified using the children's definitions as a criterion.

(*b*) Arrangements were made by courtesy of the Chief Education Officer in Leeds to examine all the pupils in twenty large secondary modern schools who were in their third year of study (3,684 pupils participated), representing about 80 per cent. of all pupils in the senior classes of non-selective secondary schools in the area. The pupils lived in all parts of the urban area and the group was representative of all children attending the secondary modern schools of the L.E.A. The children in this group had I.Q.s ranging from 70 to 115 (according to a Moray House test administered at 10-plus) and since it was evident that the wide range of ability and attainments in such a group would be reflected in their definitions of words, it was important to ensure that the definitions

obtained for each word were provided either by the whole group of pupils or a representative sample of them. It was not possible to examine many pupils on such a large number of words but precautions were taken to ensure that the definitions received for each word were representative of the whole group. The list was divided into fifty sections of about 90 words each and scripts were prepared to cover the words in each of these sections. Copies of the scripts were interleaved and were distributed in the schools serially so that each school received a proportionate number of each of the scripts and the same method of distribution was used in each class within the school. In this way, the scripts completed for each section of the list were answered by a representative group of pupils in all the classes of the participating schools. A minimum of 200 definitions was obtained for each word in the list, approximately equal numbers of boys and girls participated in the enquiry and separate records were kept for each sex.

As a number of the words in the list have more than one meaning, a decision had to be taken whether to examine children's knowledge of several meanings of the same word or only one. The number of words was so large that it did not seem possible to adopt the first alternative and the enquiry was limited accordingly to examining pupils' knowledge of one meaning of each word in the list. Each of the words in the list was presented in a brief context, the simplest way of showing the word in use, the word in the context was underlined and pupils were asked to write their definitions of it on the scripts provided. The definitions were marked according to a three-point scale (1, $\frac{1}{2}$ or 0) which provided a numerical score for each word in the list.

Such a method of enquiry has evident limitations. It assumes, for example, that meaning can be defined although this remains the central problem of semantic studies and that a scale of values exists by which definitions may be compared. There is no general agreement on the theoretical premises which might justify such assumptions and though criteria were formulated in this enquiry to help in distinguishing more consistently between good definitions and bad, the interpretation of what is good or bad is ultimately a subjective one. It has been argued, for example, that definitions which appeared to be logically and operationally incomplete could only be partially satisfactory (A *cask* of wine . . . wooden container: The *caliph* of Baghdad . . . prince): and on the same grounds, that definitions which placed a word correctly in its semantic family but omitted characteristics which would distinguish it from other words in the same family were also only partially satisfactory (He *cantered* into the yard . . . galloped: A *cleft* in the rock . . . opening). Such criteria are arbitrary and to this extent, the classification of words based upon them, must be considered a subjective one.

Secondly, the gradings which have been given to the words in the list reveal children's knowledge of them in a particular context and may give no more than an approximate indication of how well they would be understood in a different one.

Thirdly, the scope of the investigation was limited to a selection of some 4,700 of the words which children are likely to meet in reading and though this is a representative sample of the words used in the sources consulted, it is not in any way representative of all the other words which children will probably meet in reading.

D.G.B.

In spite of these limitations, the present list, which is believed to be the only one of its kind based on the performance of British children, will be of particular help to research workers and others engaged in the preparation or assessment of reading materials for pupils attending secondary modern schools. It may also be of use in the preparation of tests of attainment in reading and in estimating the difficulty of reading materials.

W.D.W.

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Mechanical Arithmetic Tests 2A and 2B. These are parallel tests devised to measure attainment in mechanical arithmetic of children in the first year of the primary school. They are fully standardised over the age range 7 : 0 to 8 : 8.

Arithmetic Progress Tests B1 and B2. These are parallel tests intended to provide an estimate of the amount of the arithmetic curriculum assimilated by children in the third year of the primary school, and are fully standardised over the age range 9 : 0 to 10 : 8.

Further details of these and the other "open" tests prepared for the use of the teacher in the classroom are given in the catalogue, *Educational Guidance in Schools: Standardised Tests for the Use of Teachers*, obtainable from the Foundation.

Test Agency

One of the aims of the Agency is to make available to users in this country the many tests originating overseas that, because of import restrictions, are difficult to obtain. In pursuance of this policy the Foundation has the agency for the distribution of tests and test materials from the Australian Council for Educational Research; the Psychological Corporation, New York; Science Research Associates, Chicago; the California Test Bureau; and many other publishers.

In addition, the Test Agency distributes in the United Kingdom and overseas a number of psychological and educational tests devised by British psychologists.

Full details and prices of all tests distributed by the Agency will be found in the new edition of the Test Agency catalogue shortly available from the Foundation.

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Test Library

As part of its service to test-users, the Foundation has built up a comprehensive library of tests and test materials. This library is available for reference at the Foundation and where possible advice and guidance on the use of tests will be given.

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